DOCUMENT RESUME

ED 043 496

SE 009 046

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TITLE	Earth-Space Science Activity Syllabus for Elementary and Junior High School Teachers of Science.
INSTITUTION	Lake County Board of Public Instruction, Tavares, Fla.
SPONS AGENCY	Bureau of Elementary and Secondary Education (DHEW/OE), Washington, D.C.
PUB DATE	Sep 68
NOTE	210p.
EDRS PRICE	EDRS Price MF-$1.00 HC-$10.60
DESCRIPTORS	Aerospace Technology, Earth Science, *Elementary School Science, *Instructional Materials, *Physical Sciences, Resource Materials, *Science Activities, *Secondary School Science
IDENTIFIERS	ESEA Title III

ABSTRACT

This syllabus is a collection of earth-space science laboratory activities and demonstrations intended for use at the elementary and junior high school levels. The activities are grouped into eight subject sections: Astronomy, Light, Magnetism, Electricity, Geology, Weather, Sound, and Space. Each section begins with brief background information, including an introduction, vocabulary list, and basic concepts. The activities are presented with objectives, materials, procedures, and, when appropriate, conclusions and suggestions for further activities. Clarifying diagrams of the equipment and material arrangements accompany most activities. This work was prepared under an ESEA Title III contract. (PR)

BESE TITLE III

ED0 43496

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EARTH-SPACE SCIENCE ACTIVITY SYLLABUS

ESEA TITLE III PROJECT

EARTH-SPACE
SCIENCE
LEARNING CENTER

TRI-COUNTY AREA IN CENTRAL FLORIDA
Citrus-Lake-Sumter

SE 009 046

ED043496

EARTH-SPACE SCIENCE LEARNING CENTER

Lake County Board of Public Instruction
Tavares, Florida

Tri-County School District

Citrus - Lake - Sumter

SCIENCE ACTIVITY SYLLABUS FOR ELEMENTARY AND JUNIOR HIGH SCHOOL TEACHERS OF SCIENCE

AN
ESEA TITLE III
PROJECT*

September, 1968

*The efforts of many people and a grant from the U.S. Office of Education, Department of Health, Education and Welfare have made this syllabus of science activities available to the classroom teachers in grades one through nine.

EARTH-SPACE SCIENCE LEARNING CENTER

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This syllabus is designed so that new activities may be added by removing the back cover.

ACKNOWLEDGEMENT

The Lake County Board of Public Instruction, the Members of the Board of Trustees, the Superintendent and Staff of the Earth-Space Science Learning Center wish to acknowledge their appreciation to *Mr. Jack Maier, **Mr. Carl Pettitt and ***the members of the Steering Committee for their cooperation and dedication in compiling this science activity syllabus.

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EARTH-SPACE SCIENCE LEARNING CENTER

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INTRODUCTION

Since World War II teachers in elementary and junior high schools have become more aware of their need for scientific knowledge in teaching their students effectively in the field of science. Studies, conducted by the supervisory staff of the project area, show that many children, on reaching high school, avoid the study of the sciences at that level. An intensive pilot-activity program has been conducted in earth-space sciences and related physical sciences in the tri-county area during the 1967-1968 school year to determine activities which would sustain their interest and would promote a desire on the part of the students to extend the study of science through their high school years.

Since many of the teachers in rural elementary and junior high schools of our area must teach all the course offerings for their grade levels, we prepared this syllabus to assist the individual teacher in presenting units of study in the earth-space sciences and related physical sciences using inexpensive materials and equipment.

ASTRONOMY

CONTENT:

INTRODUCTION

VOCABULARY

CONCEPTS

To teach students the four cardinal points (direction) and the direction in which the earth rotates.

To construct a daylight telescope.

To construct a stand for a daylight telescope.

To make constellation disks for studying the constellations.

To construct a working model reflecting telescope.

To demonstrate and explain parallax.

To construct a sun dial.

To explain and demonstrate the causes of daylight and darkness.

To explain the prism - What it is - What it does - How it works.

ASTRONOMY

INTRODUCTION

Astronomy is an old science. The ancient Babylonians, Egyptains, Greeks, Indians, and Chinese spent a great deal of time studying the location and motion of the stars in the heavens. They gave the stars and heavenly bodies names which we still use today. They even made a descriptive catalogue of the stars they could see.

Today astronomy means much more than this to man. An astronomer may study how distant stars are from the Earth and from other stars, what they are made of, how much light energy they give off, how fast they are moving, and how old they are.

In studying astronomy there are some basic terms in which students should know. Below areastronomical terms which will aid the teacher and student in developing a better understanding while studying astronomy.

VOCABULARY

1. Altitude - Elevation of an astronomical body above the horizon (in degrees). At horizon, 0 degrees at zenith 90 degrees.

2. Aperture - An opening admitting light-hole or gap.

3. Astronomy - The Science of the Stars-bodies of the universe.

4. Astronomical Unit - The distance from the Earth to the sun. 93 million miles. (A.U.)

5. Axis - A straight line, real or imaginary, passing through a rotating body and which is the line about which that body rotates

6. Azmuth - The angle, measured west along the horizon from the South point directly below a star.

7. Celestial Coordinates - Imaginary lines on the celestial sphere used to locate stars, other objects.

8. Crescent - The shape in which less than half of the face of the moon is illuminated by the Sun. New Moon and first quarter Moon third or last quarter of the Moon.

9. Declination - Angular distance in degrees north (plus) or south (minus) of the celestial equator. (equivalent to latitude on earth).

10. Ecliptic - The apparent path of the sun through the stars.

11. Eclipse - Obstruction of one celestial body by another. Usually restricted to the Sun, Moon and Satellites of other planets.

12. Equator - Line drawn around earth, halfway between North and South Pole.

13. Filament - Irregular, narrow lines seen on inside of bulb.

14. Geocentric - Viewed or considered from or referred to the center of the earth.

15. Geocentric Motion - Planet motion as observed from the earth.

16. Horizon - A line where the earth and the sky appear to meet.

17. Latitude - Angular distance North or South of the Equator, measured in degrees (0-90) along the Meridian.

18. Lunar - Pertaining to the Moon. Measured by Moon's revolutions.

19. Light Year - Measure of distance, the distance traveled by light in one year, moving at 186,000 miles per second.

20. Magnitude - Brightness of a star. The lower the number the brighter.

21. Meridian - Imaginary circle on the celestial sphere which passes through N and S points of horizon and observer's zenith.

22. Messier Objects - The hundred-odd brightest clusters, nebula, galaxies as listed by French astronomer Charles Messier (1730-1817).

23. Milky Way - The vast group of stars which includes our Sun.

24. Moon - A satellite of the earth, revolving about the earth from West to East in a little less than a calendar month.

25. Nadir - Point on the celestial sphere directly below the observer.

26. Opposition - Position of a planet when it is exactly opposite the Sun.

27. Orbit - The Path in which one body revolves about another under the gravitational attraction of the latter, as a planet or comet around the sun, or a satellite around a planet.

28. Planetarium - A complicated, multiple projector which by means of many lenses produces on a hemispherical Dome a picture of the sky with all the heavenly bodies that can be seen with the naked eye, together with their motion through days and years.

29. Planet - A large solid, spherical mass of matter that revolves in an elliptical orbit of which the sun is one of the foci.

30. Precession - Slow gyration of earth's axis. Takes 25,800 years.

31. Retrograde Motion - Backward (westward) motion of the planet among the stars, resulting from the fact that we view it from the moving earth.

32. Right Ascension - Equivalent of longitude on Earth. Measured eastward, in hours, minutes and seconds of time.

33. Satellite - A body that revolves around a planet, a moon.

34. Sidereal Day - Interval in which earth rotates once on its axis. About 4 minutes shorter than solar day.

35. Solar Day - Interval from Noon to Noon or from Sunrise to the next. Uneven in length.

36. Solar - Pertaining to the Sun.

37. Stars - Other suns, some brighter and some fainter than our sun.

38. Sun - The star around which the planets of our solar system revolve and which is the source of all light, heat, and life on the earth.

39. Sunspots - Dark blotches on the solar disc. Actually violent storms.

40. Transit - Passage of a star across the meridian.

41. Variable Stars - Stars not constant in their output of light.

42. Zenith - The point of the celestial sphere directly overhead, 90 degrees above the horizon, for any point on earth.

ASTRONOMY

I. **OBJECTIVE:** To teach the student the four cardinal points of direction and the direction in which the earth rotates.

II. **WORD STUDY:**

North
South
East
West
Sunrise
Sunset
Solar System
Equator
Rotate
Rotation
Clock-wise
Counter-clock-wise

III. **MATERIAL:**

18" Cardboard disk
Yellow water paint
Paint brush
6" Cardboard

Letters:
N-North
S-South
E-East
W-West

IV. **PROCEDURE:**

A. Cut letters from cardboard or construction paper.
B. Color 18" cardboard disk with yellow water paint.
C. 18" disk will represent Sun.
D. Have 4 students place cardinal points toward true direction along wall in classroom.
E. Have one student to hold disk to represent Sun. He should stand at the center of the South wall facing North.
F. The class should stand at their desk and face the Sun. East will be left - West to the right.
G. Instruct students to rotate left - or toward the East. This will be in a counter-clock-wise direction.
H. Continue activity until children know direction and direction of the rotation of the earth.

V. **CONCLUSION:** The earth (student) rotates from right to left, or from West to East, or counter-clock-wise as viewed from above the North Pole.

FURTHER ACTIVITIES:

The causes of day and night can be taught by these activities.

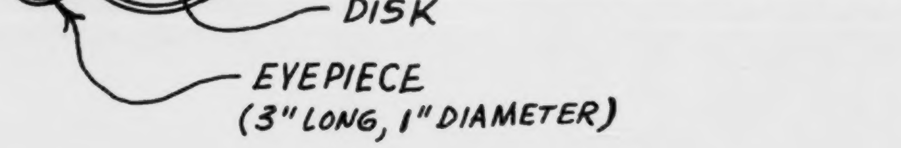
ASTRONOMY

OBJECTIVE: To construct a daylight telescope.

MATERIAL:
1 - 4" cardboard cylinder - 16" long.
(This will vary)
Masking tape.
Black construction paper.

PROCEDURE:

A. Cut disk from construction paper. This should cover outside edge of cylinder.
B. From construction paper cut rectangular piece 3-1/2" x 3-1/2" and form small cylinder for eyepiece.
C. Take the disk and cut hole in center so the eyepiece will slip into hole about 1/2 inch. Attach by using tape. (Make this light free)
D. Place eyepiece and disk over one end of cylinder. Attach by using tape.
E. Assemble as illustrated below.



FURTHER ACTIVITIES: Making mount for daylight telescope.

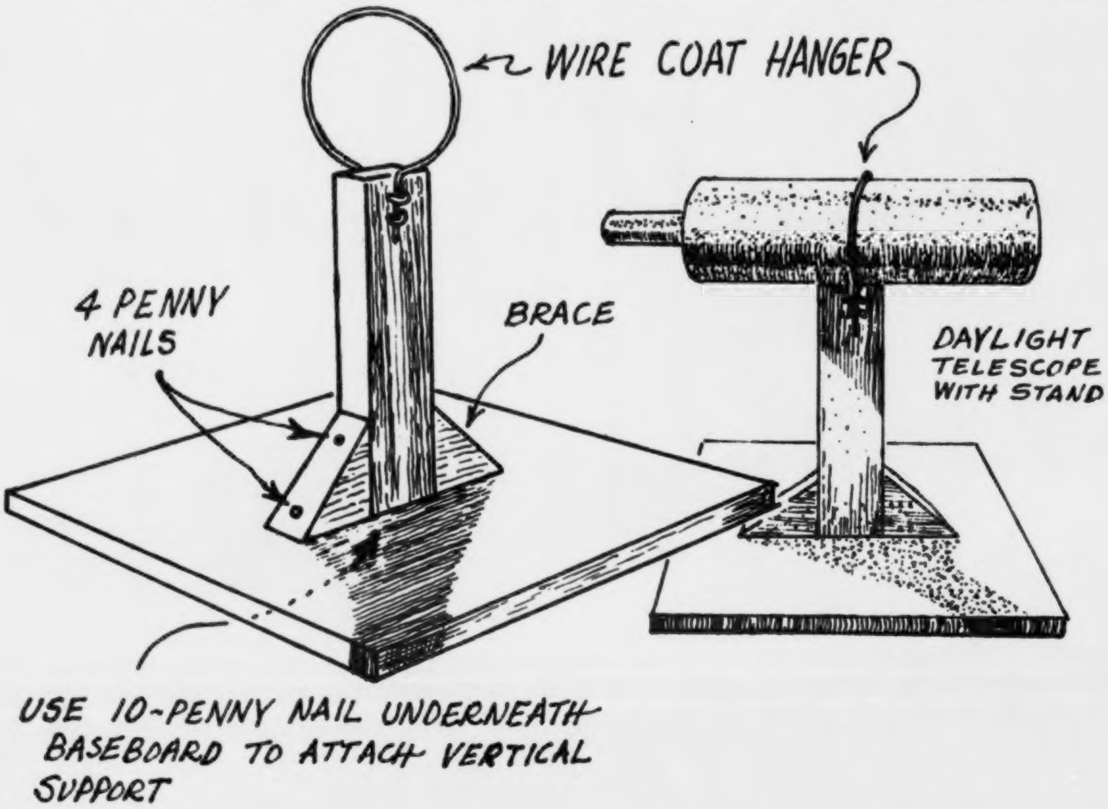
Making the constellations by punching holes in disks to form the outline of the constellations. (These disks are to be placed over the objective end of the telescope)

ASTRONOMY

OBJECTIVE: To construct a stand for a daylight telescope.

MATERIAL:
1" x 2" board - 12" long
2 triangular braces 2" for the base and altitude side.
Plywood 1/2" thick, 8" x 9" square
Wire coat hanger
8 - 4 penny finishing nails and 1 - 10 penny finishing nail.
Glue

PROCEDURE: Assemble as shown in illustration. Use glue on all joints.


WIRE COAT HANGER
4 PENNY NAILS
BRACE
DAYLIGHT TELESCOPE WITH STAND
USE 10-PENNY NAIL UNDERNEATH BASEBOARD TO ATTACH VERTICAL SUPPORT

FURTHER ACTIVITIES: Study the constellations.

ASTRONOMY

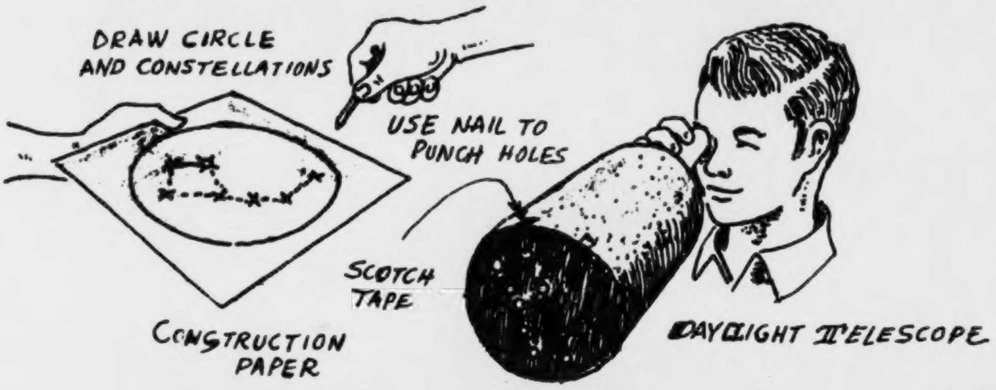
OBJECTIVE: To make constellation disks for studying the constellations.

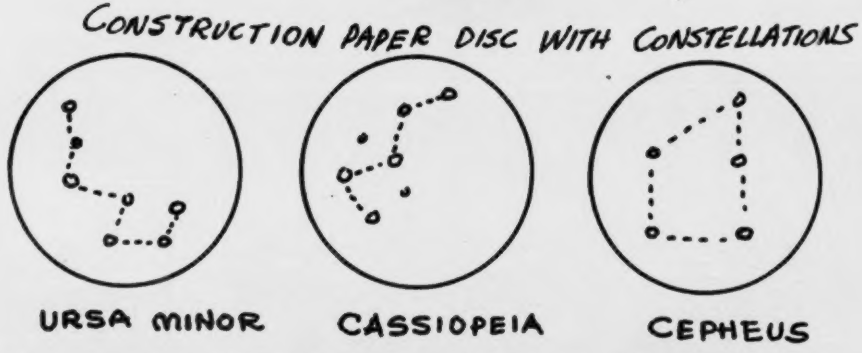
MATERIAL:

Black construction paper
Compass
Nail
Scissors
Scotch tape.

PROCEDURE:

A. Draw disks to cover outer edge of Daylight Telescope.
B. Cut out disks.
C. Use star chart to get this information.
D. Use nail by punching holes that outline the constellations being studied.
E. Note illustration below.
F. Use scotch tape to attach each disk to the objective end of the daylight telescope.


DRAW CIRCLE AND CONSTELLATIONS
USE NAIL TO PUNCH HOLES
SCOTCH TAPE
CONSTRUCTION PAPER
DAYLIGHT TELESCOPE


CONSTRUCTION PAPER DISC WITH CONSTELLATIONS
URSA MINOR
CASSIOPEIA
CEPHEUS

FURTHER ACTIVITIES: A. For studying circumpolar or seasonal constellations have the student look in the direction in which this particular constellations will be found at a specific time that night.

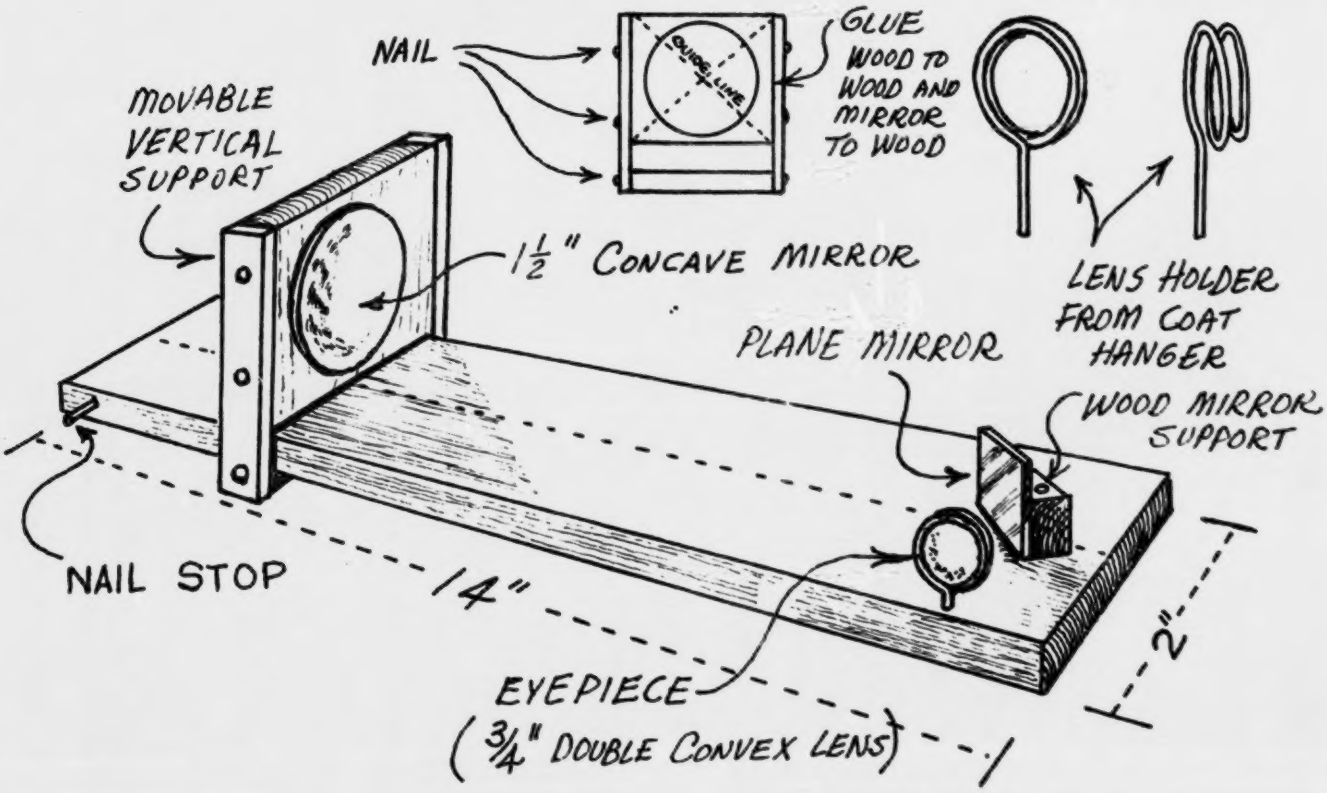
ASTRONOMY

I. OBJECTIVE: To make a working model reflecting telescope.

II. MATERIALS:

A. 1-1/2" concave mirror
B. 1" x 1-1/4" flat mirror
C. 3/4 inch double convex lens
D. Board, 3/4 inch x 2" x 4"
E. Board, 3/4" x 2" x 2-1/2"
F. 2 strips, 1/2" x 3/4" x 3"
G. 2 strips, 3/4" x 3/4" x 2"
H. Wire nails, 1-1/4" long
I. Glue
J. Wire coat hanger

III. PROCEDURE:
A. Assemble reflecting telescope as illustrated.
B. For appearance, this can be sanded, varnished and waxed, not painted.


NAIL
GUIDE LINE
GLUE
WOOD TO WOOD AND MIRROR TO WOOD
MOVABLE VERTICAL SUPPORT
1½" CONCAVE MIRROR
LENS HOLDER FROM COAT HANGER
PLANE MIRROR
WOOD MIRROR SUPPORT
NAIL STOP
14"
2"
EYEPIECE
(¾" DOUBLE CONVEX LENS)

IV: OBSERVATIONS:
A. This model actually works and can be focused by moving vertical support.
B. A reflecting telescope turns objects upside down and backwards.

V. CONCLUSION:
A. The larger concave mirror of a reflecting telescope gathers and concentrates the light of the object being viewed.
B. This concentrated light is reflected back to the plane mirror, and from there through the eyepiece (the double convex lens)

ASTRONOMY

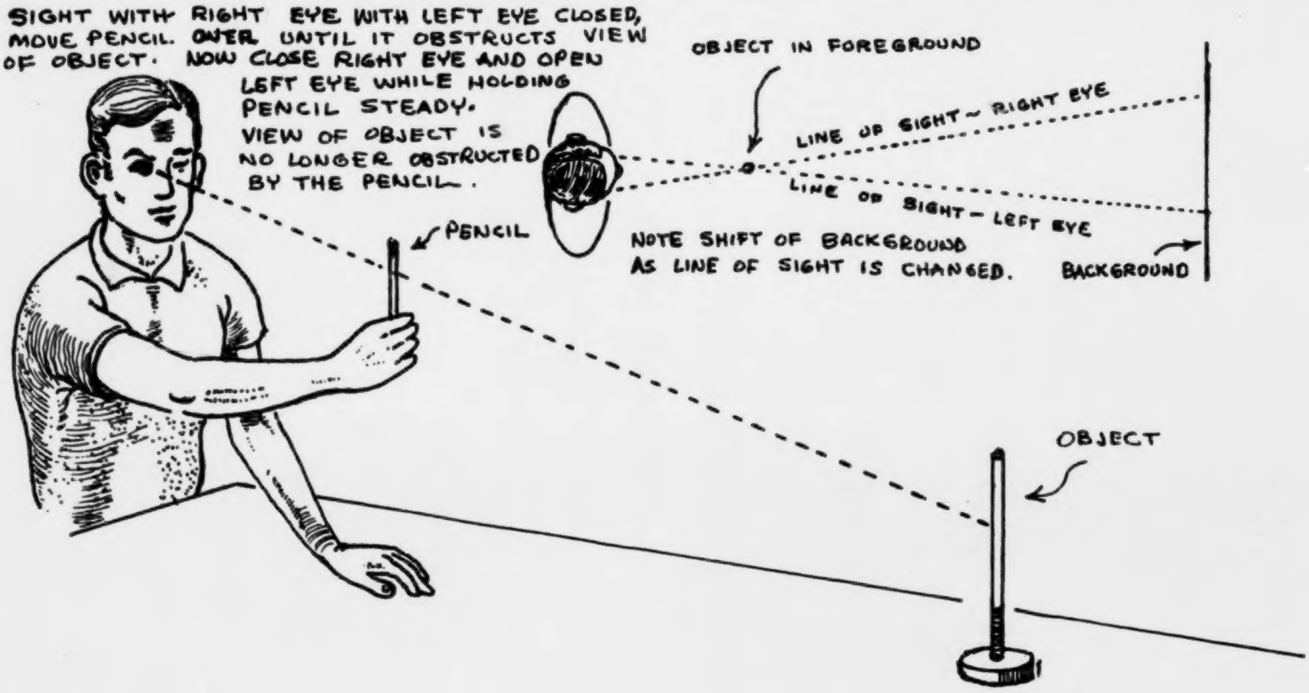
I. OBJECTIVE: To demonstrate and explain parallax.

II. MATERIALS:

A. Pen or pencil

III. PROCEDURE:

A. Hold the pen or pencil vertical at arms length at eye level.
B. Close left eye and point the pencil with an object on far wall.
C. Now close your right eye and observe where pencil is pointing.
D. With right eye closed, again align pencil with object on wall.
E. Hold pencil in same position -- open right eye and close left eye.
F. Repeat the above, - but hold pencil closer to your eyes.


SIGHT WITH RIGHT EYE WITH LEFT EYE CLOSED, MOVE PENCIL OVER UNTIL IT OBSTRUCTS VIEW OF OBJECT. NOW CLOSE RIGHT EYE AND OPEN LEFT EYE WHILE HOLDING PENCIL STEADY.
VIEW OF OBJECT IS NO LONGER OBSTRUCTED BY THE PENCIL.
OBJECT IN FOREGROUND
LINE OF SIGHT ~ RIGHT EYE
LINE OF SIGHT - LEFT EYE
PENCIL
NOTE SHIFT OF BACKGROUND AS LINE OF SIGHT IS CHANGED.
BACKGROUND
OBJECT

IV. OBSERVATIONS:

A. Pencil appeared to move to the right when B and C above were performed.
B. Pencil appeared to move to the left when D and E above were performed.
C. Apparent motion was greater when pencil was held closer to eyes.

V. CONCLUSION:

A. Parallax is the apparent movement or change of direction of an object resulting from the changing direction or position from which viewed.
B. It is expressed in terms of angular degree.
C. In astronomy, it is the apparent shift in a star's position resulting from the different positions of the earth in its orbit.
D. By observing the angular degree of a given star from two different points at the same time, the distance of that star can be calculated by geometry.

ASTRONOMY

E. **ERATOSTHENES**, a Greek astronomer who lived between the years of 276 and 194 B.C. used mathematics and parallax to calculate the circumference of the earth at 25,000 miles-------- amazingly close to the true circumference of about 24,900 miles.

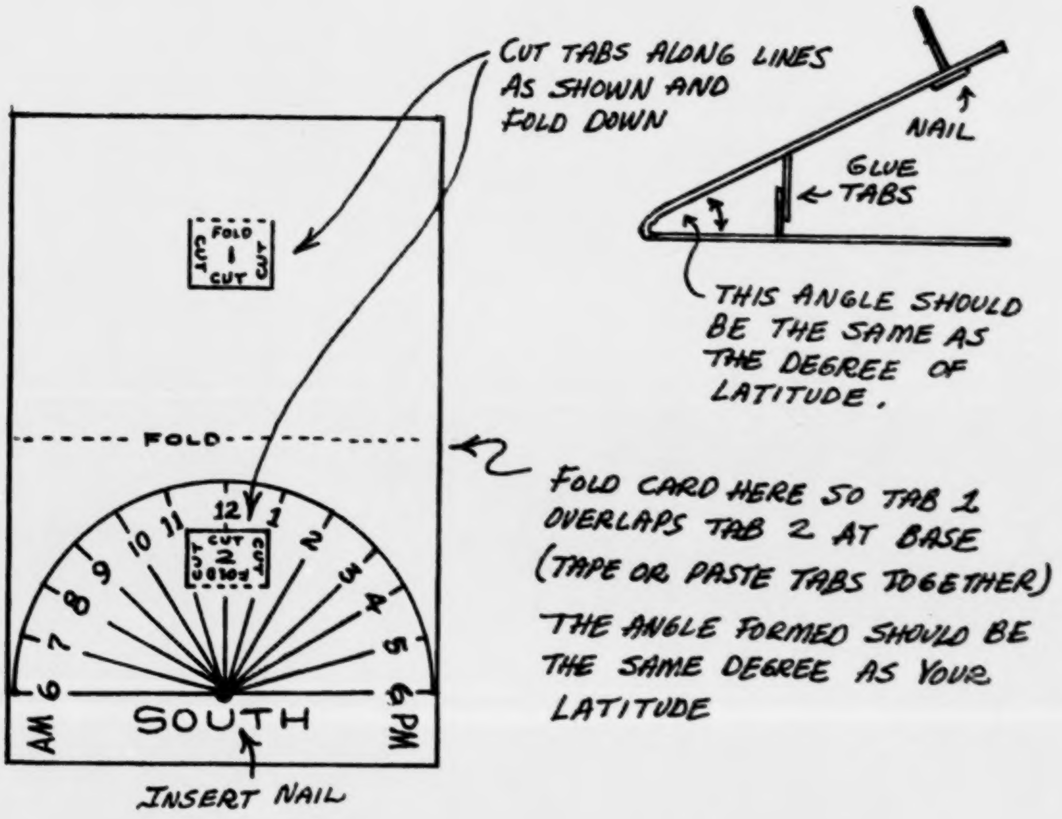
The angular degree between Alexandria and Syene was 7 1/2 degrees on the same day.

ASTRONOMY

OBJECTIVE: To construct a Sun Dial.

MATERIAL:
5" x 8" card
Straight edge (ruler)
Protractor or compass
Pencil
4 penny shingle nail
Scissors or razor blade
Scotch tape or paste

PROCEDURE: Construct as shown in illustration below.


NAIL
GLUE TABS
FOLD
1
CUT
CUT
CUT
FOLD
12
1
2
3
4
5
6
PM
11
10
9
8
7
6
AM
CUT
2
CUT
CUT
CUT
SOUTH
INSERT NAIL

CUT TABS ALONG LINES AS SHOWN AND FOLD DOWN

THIS ANGLE SHOULD BE THE SAME AS THE DEGREE OF LATITUDE.

FOLD CARD HERE SO TAB 1 OVERLAPS TAB 2 AT BASE (TAPE OR PASTE TABS TOGETHER)

THE ANGLE FORMED SHOULD BE THE SAME DEGREE AS YOUR LATITUDE

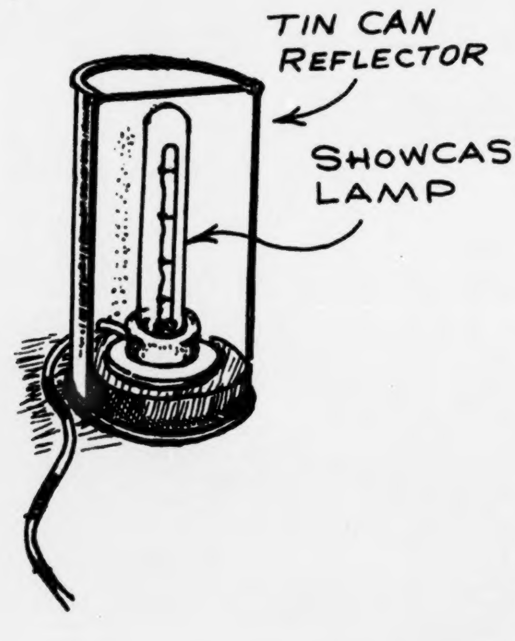
FURTHER ACTIVITIES: Study apparent solar time. Know parts of a sun dial.

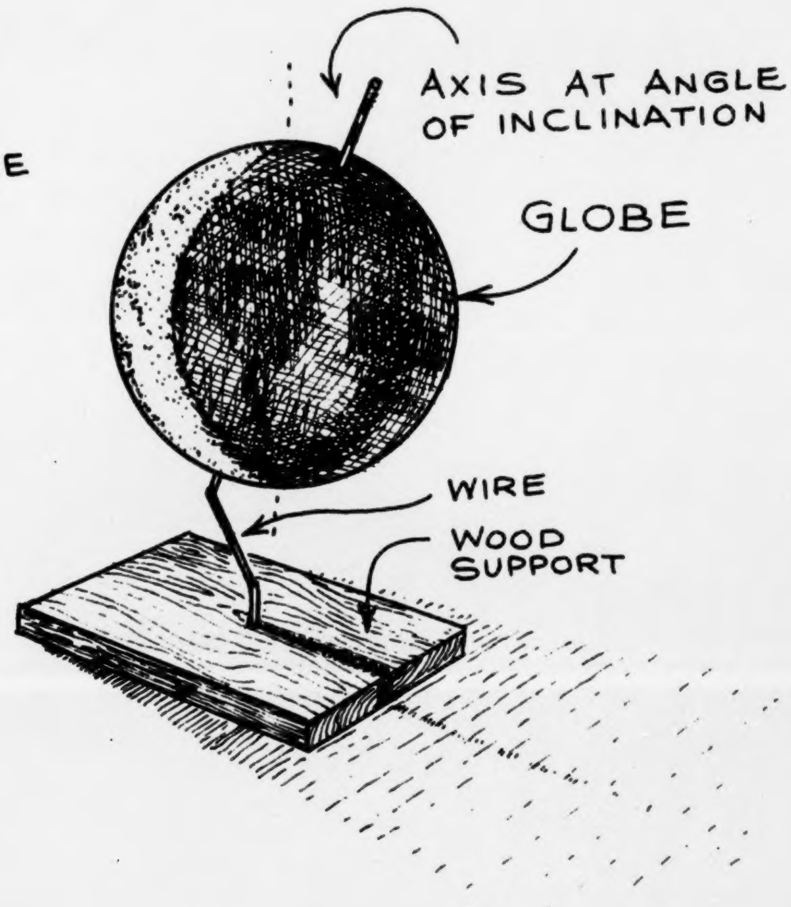
ASTRONOMY

I. **OBJECTIVE**: To explain and demonstrate the causes of daylight and darkness.

II. **MATERIALS**:

A. Glue of the world
B. Glue
C. Glitter
D. Flashlight or showcase incandescent lamp
E. Can
F. Wire coat hanger
G. Tin snips
H. Toothpick and small piece of paper, small bit of modeling clay


TIN CAN REFLECTOR
SHOWCASE LAMP


AXIS AT ANGLE OF INCLINATION
GLOBE
WIRE
WOOD SUPPORT

III. PROCEDURE:

A. Make a small triangular flag, attach to the toothpick, add glue to each side and cover with glitter.
B. Using the bit of modeling clay, attach the flag to your geographic location on the globe.
C. Using the tin can, coat hanger and tin snips, make a reflector that will cover one side of the showcase lamp.
D. Set up this equipment as illustrated, with the exposed part of the showcase lamp pointing away from the students.
E. Darken the room as much as possible.
F. Slowly rotate the globe toward the east: Watch the glitter on the flag to catch the beam at "sunrise" and the last beam at "sunset".
G. Have the students determine when it is Noon at their location.
H. Have the students determine when it is Midnight at their location.

IV. OBSERVATIONS:

A. As the earth is rotated toward the east, the flag catches the first rays of "sunlight" as it comes just over the horizon, indicating dawn or the beginning of daylight.

B. When the flag is pointed directly at the sun, it would be Noon.

C. As the flag goes down over the horizon, catching the last rays of sunlight, dusk is beginning and will be followed by darkness.

V. CONCLUSION:

Daylight and darkness are caused by the rotation of the earth on its axis, making it appear that the sun is revolving around the earth.

ASTRONOMY

I. OBJECTIVE: The prism---What it is---What it does---How it works

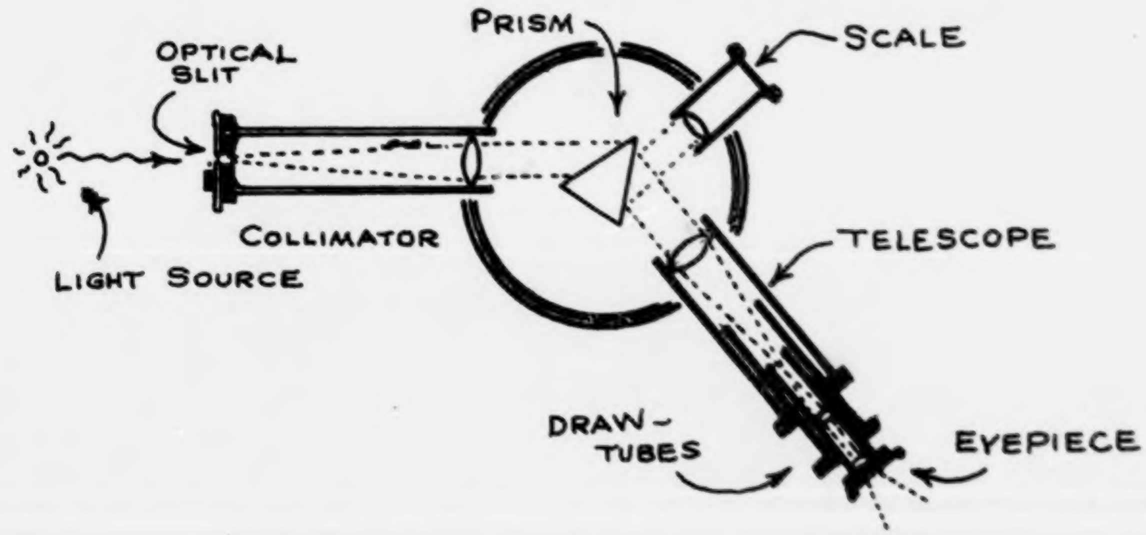
II. MATERIALS:

A. Large drawing of the spectroscope
B. If possible, a spectroscope

III. PROCEDURE:

A. Using the diagram, and if available, the spectroscope, point out the various parts of the spectroscope and explain their functions.

B. If a spectroscope is available, allow the students to observe the light from an incandescent light and fluorescent light. Compare the spectra.



IV. THE SPECTROSCOPE:

A. Spectroscope: an optical instrument used to examine the spectrum of any luminous source.

1. Collimator: is a tube with a narrow slit at one end and a converging lens at the other to produce parallel light rays.

2. PRISM: to break up the white light into the component colored rays, --- the spectrum.

3. Telescope: consists of a tube with lenses and an eyepiece and is for observing the spectrum produced.

4. Scale: attached to the spectroscope and used for making precise measurements of spectral wave lengths or the index of refraction.

B. Spectrometer: simply a spectroscope fitted with a scale as in #4.

C. Spectrograph: simply a spectroscope fitted for photographing a spectrum.

D. Spectrogram: a photograph of the spectrum.

V. ADDITIONAL INFORMATION:

A. Most substances will glow when heated and changed to gases. Each substance, when luminous, emits a characteristic spectrum, unlike that of any other substance, with definite lines that are always in the same position.

B. Scientists use this knowledge to indentify the elements and compounds of which the various planets and their atmosphere are composed. -----Also in determining the composition of our sun and other stars.

LIGHT

CONTENT:

INTRODUCTION

VOCABULARY

CONCEPT

The parts of the eye and their function.

To show that light travels in a straight line in all directions from its source.

To explain and demonstrate the difference between a "real image" and a "virtual image."

To demonstrate the forming of "virtual" and "real" images with various types of lenses.

To demonstrate and explain the "focal point" and "focal length" of a lens or mirror.

To demonstrate and explain: transparent - translucent - and opaque.

Two ways to demonstrate refraction.

To demonstrate that the angle at which light rays enter a substance effects the refraction.

To demonstrate and explain an optical illusion.

To demonstrate that the color of an object is determined by colors of the light it reflects and absorbs.

To show how the camera is like the eye.

LIGHT

(continued)

To demonstrate that light rays travel in a straight line. To demonstrate how a pinhole camera works.

To make a spectroscope.

To construct a periscope and explain how it works.

To explain the incandescent lamp and how it works.

To explain how the fluorescent light works.

LIGHT

INTRODUCTION

1. What is light?

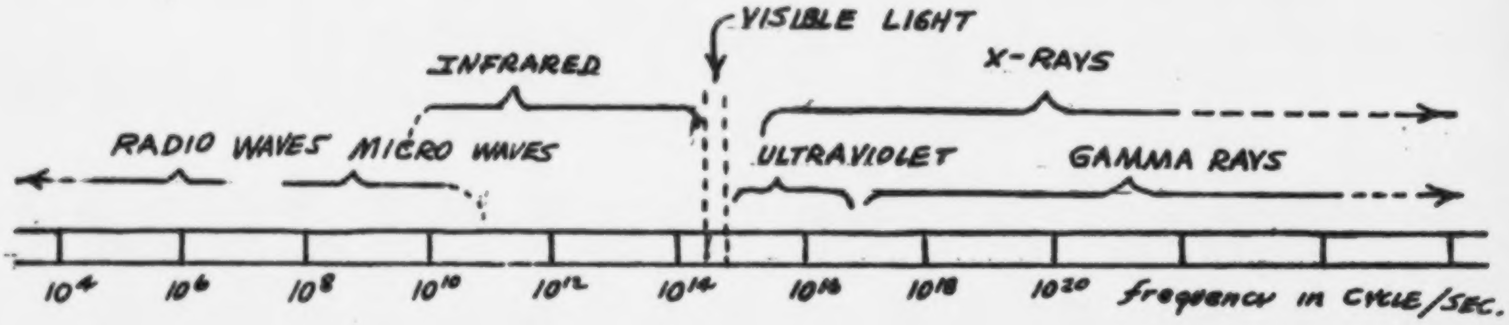
A form of radiant energy to which the human eye is sensitive. Produced by rapid vibrations of certain types of electromagnetic waves and particles called photons.

2. Where does light come from?

Generally speaking, the light that gives us daylight comes from the sun. However, this radiant energy that we interpret as light may be transformed from other forms of energy; chemical energy to light during combustion; electrical energy to light in the various lighting devices.

3. Is our eye sensitive to all radiant energy from the sun or otherwise?

No. The visible spectrum is but a very small part of the electromagnetic spectrum which is emitted in the form of radiant energy from the sun.


VISIBLE LIGHT
INFRARED
X-RAYS
RADIO WAVES
MICRO WAVES
ULTRAVIOLET
GAMMA RAYS
10^4
10^6
10^8
10^{10}
10^{12}
10^{14}
10^{16}
10^{18}
10^{20}
frequency in CYCLE/SEC.

4. Just what does the visible spectrum consist of?

It is that band of white light to which the eye is sensitive and is made up of the primary colors:

R	O	Y	G	B	I	V
E	R	E	R	L	N	I
D	A	L	E	U	D	O
	N	L	E	E	I	L
	G	O	N		G	E
	E	W			O	T

This is the order of the colors of the visible spectrum. Red has the longest wave length and violet has the shortest wave length to which the eye is sensitive.

5. What is meant by infrared?

These are invisible rays just beyond the red of the visible spectrum: their waves are longer than those of the visible spectrum and they have a penetrating heating effect.

6. What is ultraviolet light?

Ultraviolet light is light of extremely short wave length and lying just beyond the violet end of the visible spectrum. The wave length is too short to be detected by the eye. The ultraviolet rays are the rays which give us a sunburn or suntan.

7. How does light reach us from its source?

Light travels in a straight line in all directions from its source in rays. These rays are in the form of waves and vibrating particles called photons.

8. What is the speed of light?

Light travels at a speed of about 186,000 miles per second. It takes light eight minutes to reach the earth from the sun.

9. Can light rays be bent?

Yes. This "bending" is called refraction. It can be accomplished when a ray of light passes through one medium to another of different density and at an angle. A prism is used for this purpose when studying light, and moisture in the atmosphere acts as a prism causing a rainbow to form.

10. What is fluorescence?

The property of a substance to produce light when acted upon by radiant energy such as ultraviolet light or X rays. Fluorite and certain other minerals are fluorescent under ultraviolet light.

11. What is phosphorescence?

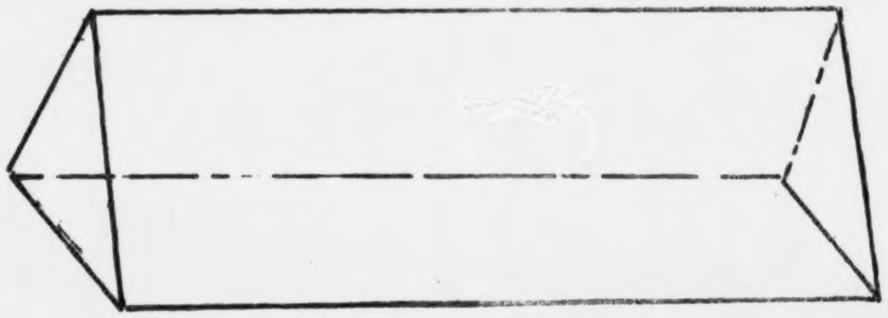
The property or condition of giving off light without noticeable heat or combustion, as shown by phosphorus in the dark, certain decaying wood, lightning bugs, (fire flies) and certain minerals that have been exposed to ultraviolet light.

12. What is incandescence?

The property or condition of glowing with intense heat, especially white-hot, such as the sun, a filament light bulb, or a piece of metal heated until it is white-hot and gives off light.

13. What is a prism?

A piece of polished glass whose ends are equal and parallel triangles and whose three sides are parallelograms. The ends not polished. It is used for refracting light rays into the spectrum.



14. What is a diffraction grating?

A diffraction is a plate of glass, clear plastic or polished metal ruled with a series of very close, equidistant, parallel lines and is used to produce a spectrum by the diffraction of reflected or transmitted light. They are ruled 600 lines or grooves per mm.

15. What is a spectroscope and what is it used for?

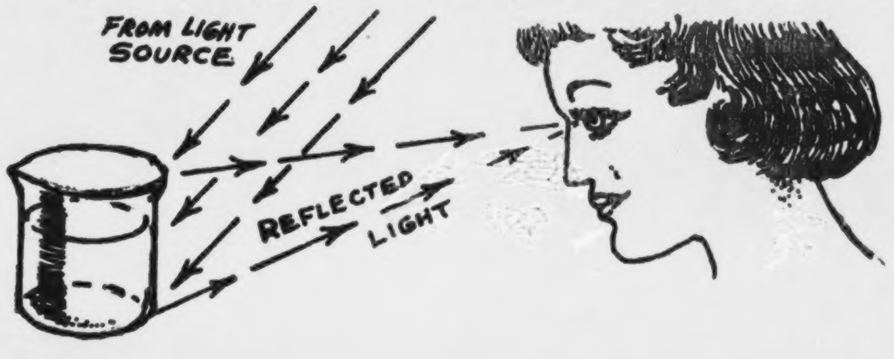
It is an optical instrument used to form spectra for study, especially of reflected light of various elements and compounds and the transmitted light of stars. It is the use of the spectroscope that has enabled scientists to determine the composition of the atmosphere of the various planets. Each element refracts light in its own way, thus making it possible to identify each element by its spectrum and even the majority of the various compounds.

16. What is the difference between "luminous" and "illuminated?"

A "luminous" body gives off light. An "illuminated" body is lighted from a source other than itself.

17. Since most objects are not "luminous" or "incandescent", how do we see the various objects?

We see them by reflected light from some luminous or incandescent object. Reflected light comes from the object to the eyes.



LIGHT
IMPORTANT TERMS

1. MIRROR: Any smooth surface that reflects the image of objects; especially a piece of glass coated on the reverse side with silver.

2. PLANE MIRROR: Any mirror whose reflecting side is flat.

3. CONCAVE MIRROR: Any mirror whose reflecting side curves inwards towards the center and away from the object.

4. CONVEX MIRROR: Any mirror with the center curving outward towards the object.

5. REFLECT: In the case of light, to bend back the rays of light in the direction from which they came, or to produce an image.

6. FOCAL LENGTH: The distance from the center of a lens or mirror to the point where the refracted or reflected rays converge. (meet)

7. FOCAL POINT: The point where the rays of light reflected by a mirror or refracted by a lens converge. (meet)

8. REFRACTION: The bending of light rays as they pass from a medium of one density to a medium of another density.

9. LENS: A piece of transparent material having at least one curved surface and capable of refracting light.

10. CONVEX LENS: A lens with one side curving outwards from the center towards the object.

11. DOUBLE CONVEX LENS: A lens with both surfaces curving outwards from the center.

12. CONCAVE LENS: A lens whose surface curves inwards towards the center.

13. DOUBLE CONCAVE LENS: A lens whose two surfaces curve inwards to the center and away from the object.

14. COMPOUND LENS: A lens made up of two or more lenses. Most cameras, telescopes, microscopes, binoculars, etc. have compound lenses.

15. MAGNIFY: To make an object appear larger.

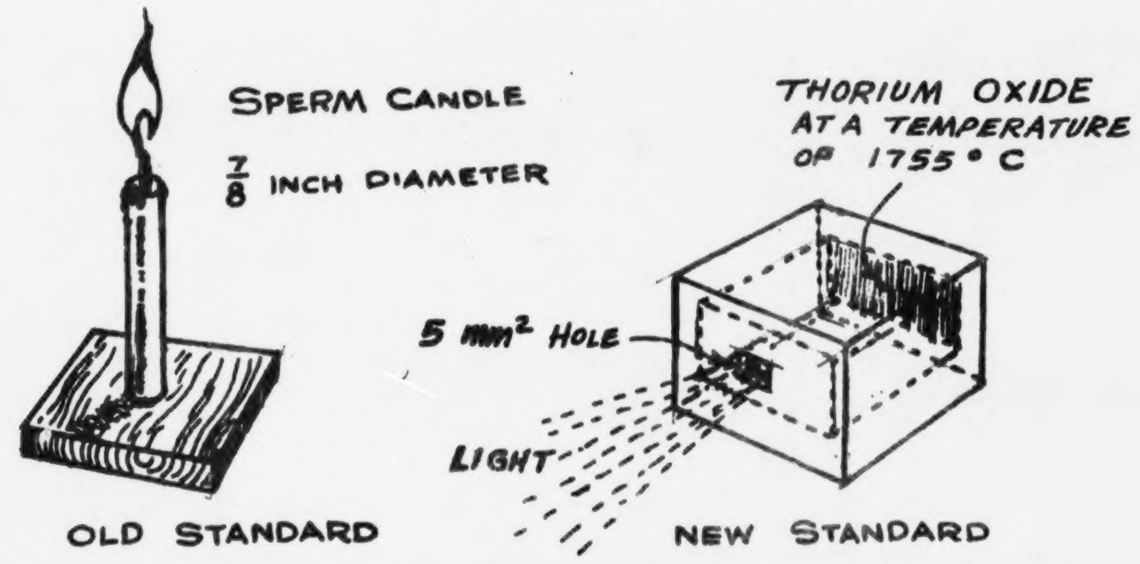
16. MAGNIFYING GLASS: Any lens that will magnify.

17. IMAGE: The visual impression of an object produced by reflection from a mirror or refraction by a lens.

18. OBJECT: A material thing that can be seen or touched; that material thing at which a mirror or lens is aimed.

19. **CANDLE POWER**: A unit of measure used to indicate the strength of a light source. This term came from the orginal standard, a burning candle, which has been replaced by the light emitted by thorium oxide when it is heated to a temperature of 1755 degrees C., the temperature of melted platinum. A square centimeter hole is cut in a box and the light emitted from this hole has a strength of 60 candlespower. The intensity of other lights are standardized by comparing with this.

1 CANDLE POWER


SPERM CANDLE
$\frac{7}{8}$ INCH DIAMETER
THORIUM OXIDE AT A TEMPERATURE OF 1755 ° C
5 mm² HOLE
LIGHT
OLD STANDARD
NEW STANDARD

20. **FOOT CANDLE**: The intensity of illumination on a surface one foot from a standard candle.

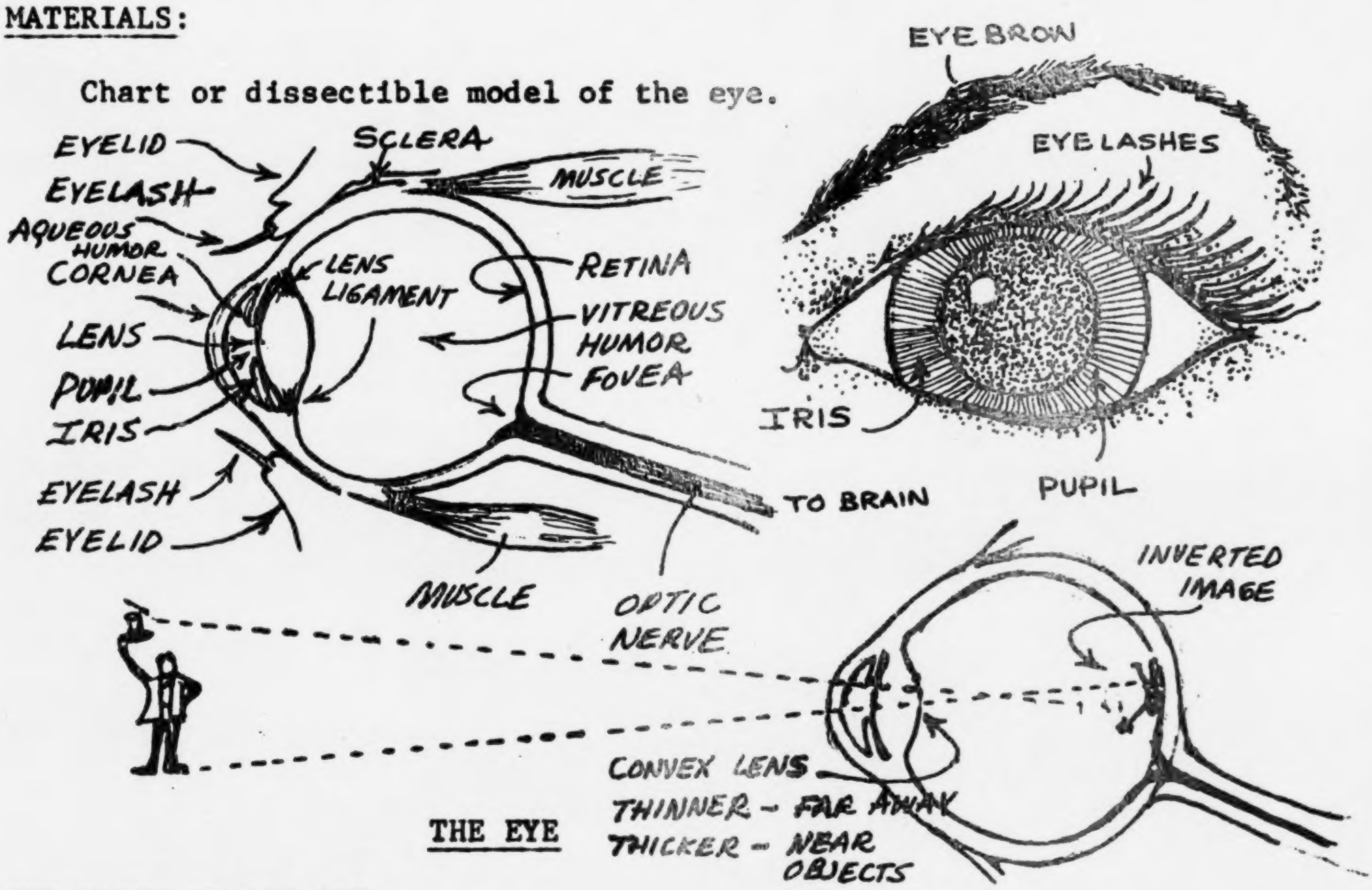
21. **LIGHT METER**: An instrument for measuring the intensity of light in foot candles. It contains a photoelectric cell which is sensitive to light.

LIGHT

I. OBJECTIVE: The parts of the eye and their functions.

II. MATERIALS:

Chart or dissectible model of the eye.


EYELID
EYELASH
AQUEOUS HUMOR
CORNEA
LENS
PUPIL
IRIS
EYELASH
EYELID
SCLERA
MUSCLE
LENS LIGAMENT
RETINA
VITREOUS HUMOR
FOVEA
TO BRAIN
MUSCLE
OPTIC NERVE
EYE BROW
EYE LASHES
IRIS
PUPIL
INVERTED IMAGE
CONVEX LENS
THINNER - FAR AWAY
THICKER - NEAR OBJECTS

THE EYE

III. THE PARTS OF THE EYE:

A. CORNEA: A thin transparent covering over the front of the eyeball. It protects the iris and pupil.

B. AQUEOUS HUMOR: Transparent, colorless substance between the cornea and the iris, it acts as a lens bending the light to some extent.

C. IRIS: That part of the eye that contains the coloring matter (pigment), giving the eyes their brown, blue or green color. It surrounds the pupil and opens and closes like a diaphram on a camera, allowing the correct amount of light to enter.

D. PUPIL: Is just the hole or opening in the middle of the iris through which the light enters the eye.

E. LENS: It is directly behind the pupil. It gets thinner or thicker so that light that enters the eye is properly focused and the object can be seen clearly. Muscles and ligaments control the focusing of the lens.

F. VITREOUS HUMOR: A transparent, colorless, jellylike substance that fills the eyeball between the lens and the retina. It acts as a lens, bending the light to some extent.

G. RETINA: The innermost coat of the back part of the eyeball containing a layer of cells sensitive to light. The image formed by the lens is focused on the retina and is directed to the brain by way of the optic nerve. The retina of the eye might be compared to the film in a camera.

H. OPTIC NERVE: The nerve cells of the retina come together to form this nerve. It carries the image of the object to the brain where it is interpreted as sight, or what we see.

I. SCLERA: Is the tough, white, fibrous membrane covering all of the eyeball except that area covered by the cornea.

J. EYELIDS: Close automatically by reflex to protect the eye from foreign objects.

K. EYE BROWS-EYE LASHES: Help keep dust and other matter out of the eye.

L. HOLLOW BONY SOCKET: Bone above and below for protection.

M. TEAR DUCTS: Secrete a salty solution that lubricates the eyeball.

LIGHT

I. **OBJECTIVE:** To show that light travels in a straight line in all directions from its source.

II. **MATERIALS:**

- A. Three pieces of cardboard about six inches squars.
- B. Paper punch or other device for punching holes.
- C. A light source, ------- candle or small incandescent lamp.

III. **PROCEDURE:**

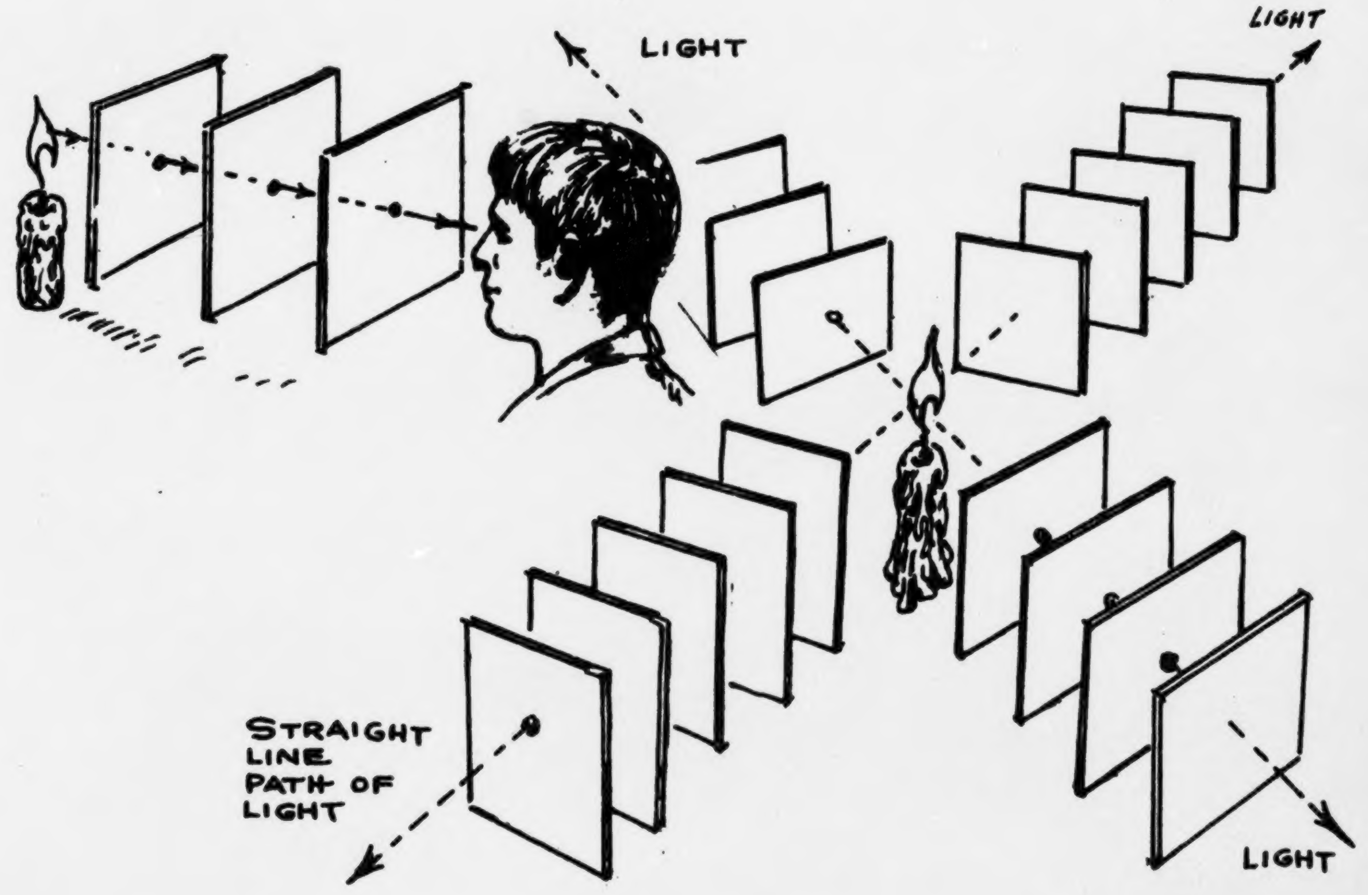
A. Holding the three pieces of cardboard together, punch a hole through all three at the same time.

B. Arrange the cards so that the source of light can be seen by looking through the holes.

How are the cards arranged when this is possible?

C. Move the cards to many positions around the source of light and arrange so that the light can be seen.

Can the light be seen from all positions if the cards are arranged properly?


LIGHT
LIGHT
STRAIGHT LINE PATH OF LIGHT
LIGHT

IV. OBSERVATION:

A. The holes were in a straight line when the source of light could be seen.

B. The source of light could be seen from any position providing the holes were in line.

V. CONCLUSION:

Light travels in a straight line in all directions from its source.

LIGHT

I. **OBJECTIVE:** To explain and demonstrate the difference between a "real image" and "virtual image".

II. **MATERIALS:**

- A. Plane mirror
- B. Concave mirror
- C. Convex mirror
- D. Candle
- E. Piece of white paper

III. **PROCEDURE:**

A. Place a lighted candle closer to the concave mirror than the focal length.

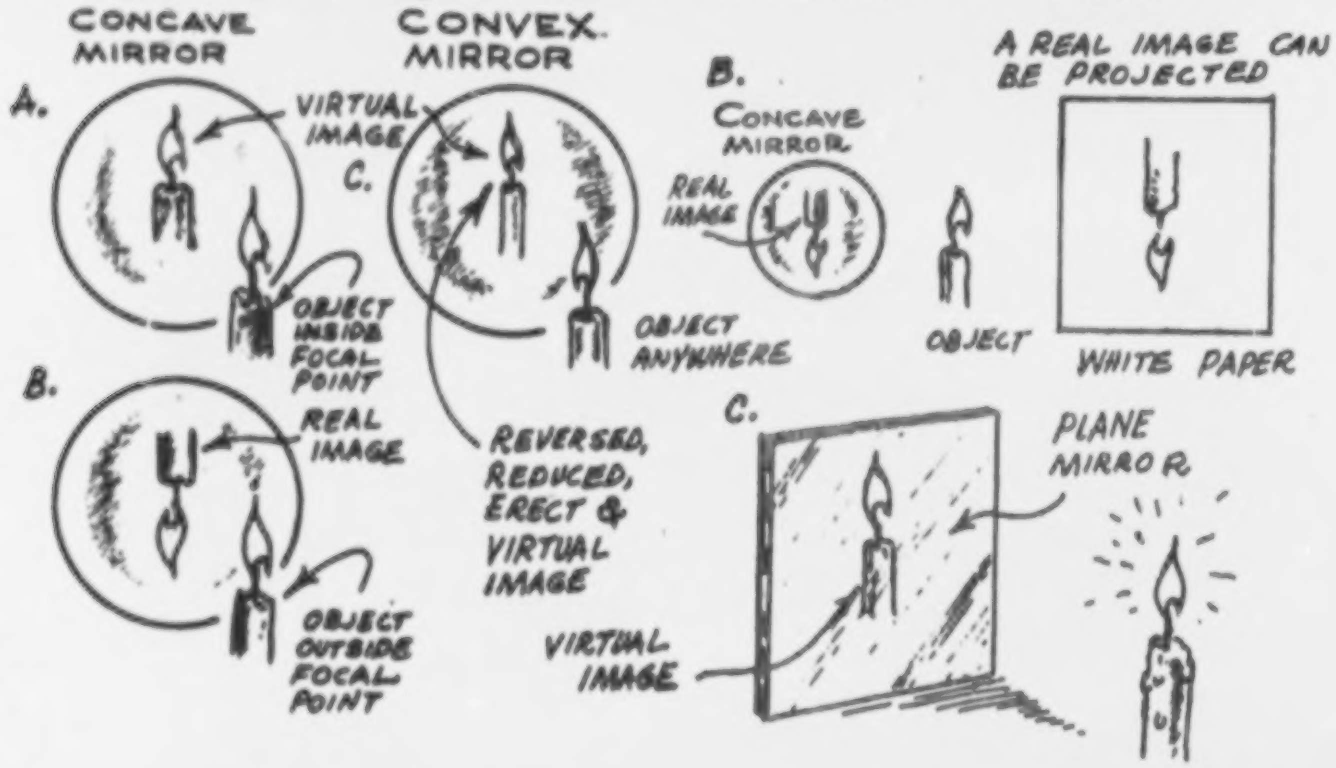
1. What kind of an image is formed in the mirror?
2. Can this image be formed on a piece of paper? Hold the paper at varying distances in front of the mirror.

B. Hold the candle further away from the mirror than its focal length.

1. What kind of an image is formed in the mirror?
2. Can this image be formed on a piece of paper? Hold the paper at varying distances in front of the paper.

C. Place the candle at different distances from the convex and plane mirrors and observe.

1. Can the image be cast on the paper?
2. What kind of image is formed in the mirror in each case?


CONCAVE MIRROR
A.
VIRTUAL IMAGE
OBJECT INSIDE FOCAL POINT
B.
REAL IMAGE
OBJECT OUTSIDE FOCAL POINT
CONVEX MIRROR
C.
OBJECT ANYWHERE
REVERSED, REDUCED, ERECT & VIRTUAL IMAGE
B.
CONCAVE MIRROR
REAL IMAGE
OBJECT
A REAL IMAGE CAN BE PROJECTED
WHITE PAPER
C.
PLANE MIRROR
VIRTUAL IMAGE

IV. OBSERVATIONS:

A. When the candle was held closer to the concave mirror than its focal length, the image formed was up-right and increased in size. This image could not be cast on the paper, and appeared to be behind the mirror.

B. When the candle was held outside the focal point of the concave mirror, the image formed in the mirror was reduced in size and inverted. It appeared to be on the surface of the mirror. This image could be cast on the paper and was also inverted.

C. When the candle was held at varying distances from the convex mirror, the image was up-right, reversed and reduced in size and could not be cast on a screen. It appeared to be behind the mirror.

D. The image formed by the plane mirror was also reduced in size, was up-right, reversed and could not be cast on the paper.

V. CONCLUSION:

A. A real image is one that can be cast on a screen. It is formed by a concave mirror and is always inverted. It may be enlarged or reduced in size.

B. A virtual image is one that cannot be cast on a screen and appears to be behind the mirror. It is formed by plane mirrors, convex mirrors, and inside the focal length of the concave mirror. It is always in an up-right, but reversed position. Virtual images may be enlarged or reduced in size.

LIGHT

I. **OBJECTIVE:** To demonstrate the forming of "virtual" and "real" images with various types of lenses.

II. **MATERIALS:**

- A. Convex lens
- B. Concave lens
- C. Sheet of plain white paper
- D. Pencil

III. **PROCEDURE:**

A. Hold the convex lens closer to an object than the focal length of the lens.

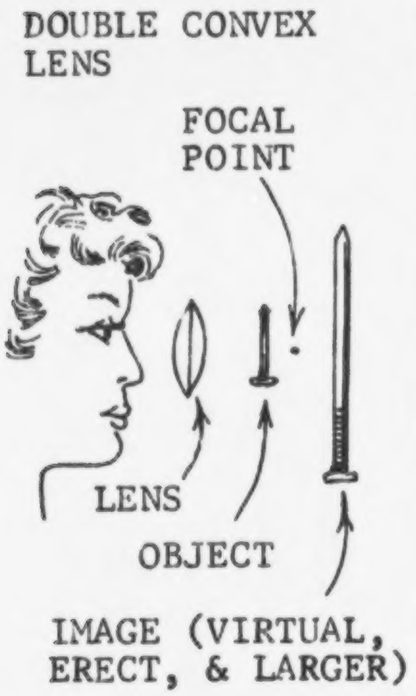
1. Was the object viewed inverted or upright?
2. Can the image be cast on the sheet of paper?
3. Is the image viewed through the lens larger or smaller than the object?

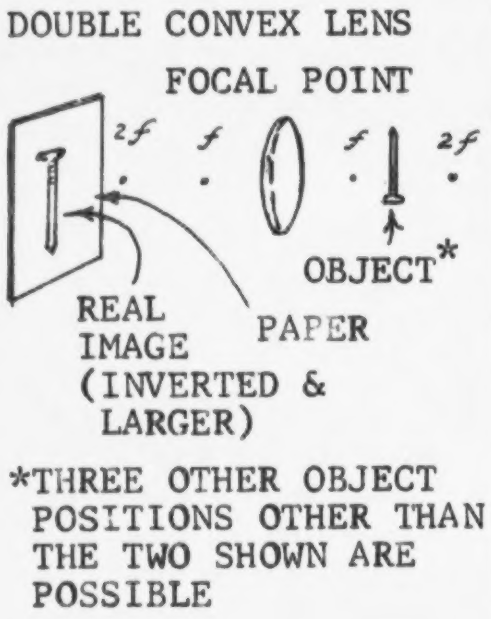
B. Hold the object outside the focal point of the lens.

1. Is the object viewed inverted or upright?
2. Can the image be cast on the sheet of paper?
3. Is the image viewed through the lens larger or smaller than the object?

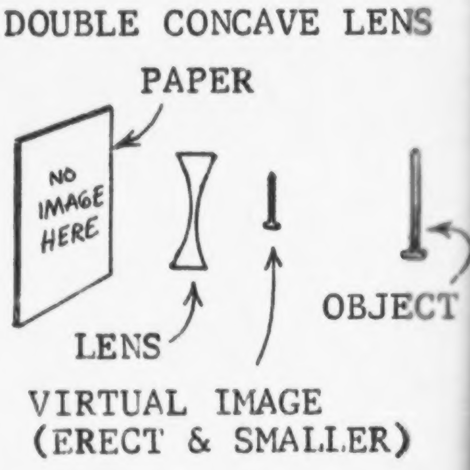
C. Hold an object at varying distances from the concave lens and observe.

1. Is the object viewed inverted or upright?
2. Can the image be cast on the sheet of paper?
3. Is the image viewed through the lens larger or smaller than the object?


DOUBLE CONVEX LENS
FOCAL POINT
LENS
OBJECT
IMAGE (VIRTUAL, ERECT, & LARGER)


DOUBLE CONVEX LENS
FOCAL POINT
2f
f
f
2f
OBJECT*
REAL IMAGE (INVERTED & LARGER)
PAPER

*THREE OTHER OBJECT POSITIONS OTHER THAN THE TWO SHOWN ARE POSSIBLE


DOUBLE CONCAVE LENS
PAPER
NO IMAGE HERE
OBJECT
LENS
VIRTUAL IMAGE (ERECT & SMALLER)

IV. OBSERVATIONS:

A. Images appear to be enlarged and are up-right when the object is placed inside the focal point of the convex lens. This image cannot be cast on the paper. It is a virtual image.

B. When the object is held further from the lens than the focal point of the lens, the image is smaller than the object, is inverted and can be cast on the paper. It is a real image.

C. When an object is viewed through the concave lens, regardless of its distance from the lens, its image is up-right and appears smaller. The image cannot be cast on the paper. This is a virtual image.

V. OBJECTIVE: To demonstrate the forming of "virtual" and "real" images with the various types of lenses.

VI. CONCLUSION:

A. Convex lenses form virtual images when the object is inside the focal point of the lens. They may be enlarged or reduced in size.

B. Virtual images only are formed by concave lenses. They are always erect and may be enlarged or reduced in size.

C. Virtual images cannot be projected on a screen.

D. Convex lenses form real images when the object is outside the focal point of the lens. Real images are always inverted and may be enlarged or reduced in size. They can be projected on the screen.

LIGHT

I. **OBJECTIVE:** To demonstrate and explain the "focal point" and "focal length" of a lens or mirror.

II. **MATERIALS:**

A. Concave shaving mirror
B. Magnifying lens, one or more
C. Sheet of plain white paper
D. Sun
E. Ruler with metric measurements

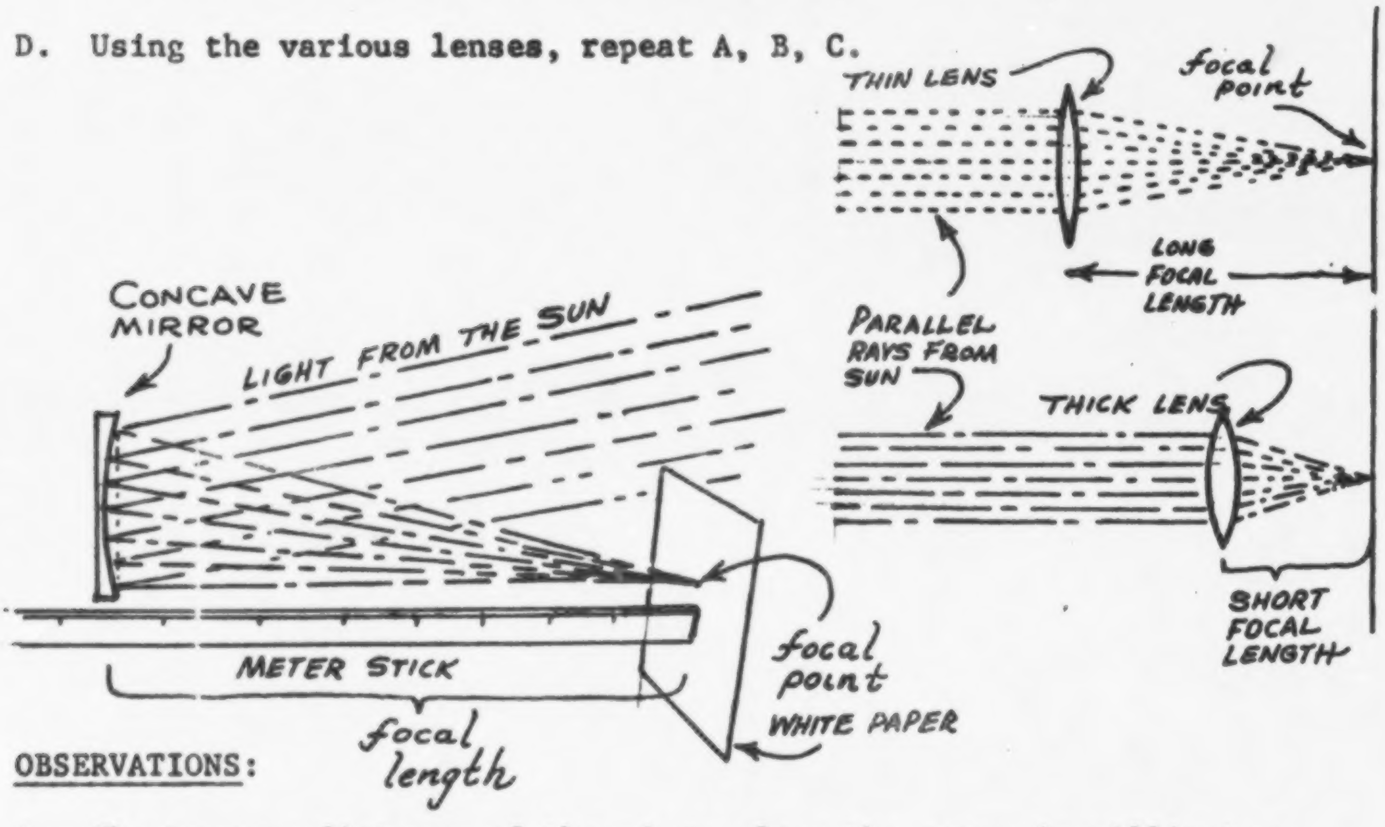
III. **PROCEDURE:**

A. Face the concave mirror towards the sun while holding the sheet of white paper in front of the mirror so that the sun's rays are reflected onto the paper.

B. Position one end of the metric measure against the paper and move the mirror slowly back and forth against the measure until the reflected light is concentrated into the smallest spot possible.

C. Repeat this several times while checking the distance of the center of the mirror from the paper in millimeters. (mm) Record these distances and take the average.

D. Using the various lenses, repeat A, B, C.


THIN LENS
focal point
LONG FOCAL LENGTH
PARALLEL RAYS FROM SUN
THICK LENS
SHORT FOCAL LENGTH
CONCAVE MIRROR
LIGHT FROM THE SUN
METER STICK
focal point
WHITE PAPER
focal length

IV. **OBSERVATIONS:**

A. The average distance of the mirror from the paper in millimeters________

B. The average distance of the lens from the paper in millimeters________

If more than one lens or mirror is used, record averages for each.

V. CONCLUSION:

A. The point where the bright spot of light is formed is called the focal point: This is the point where the rays of light reflected by a mirror or refracted by a mirror converge. (meet)

B. Focal Length of a mirror or lens is the distance from the center of the lens or mirror to the point where the reflected or refracted rays meet. This is always given in millimeters, and can be determined very accurately. In our situation above, the average we arrived at would be very close.

The thicker the lens, the shorter the focal length.

LIGHT

I. OBJECTIVE: To demonstrate and explain: transparent, translucent, and opaque.

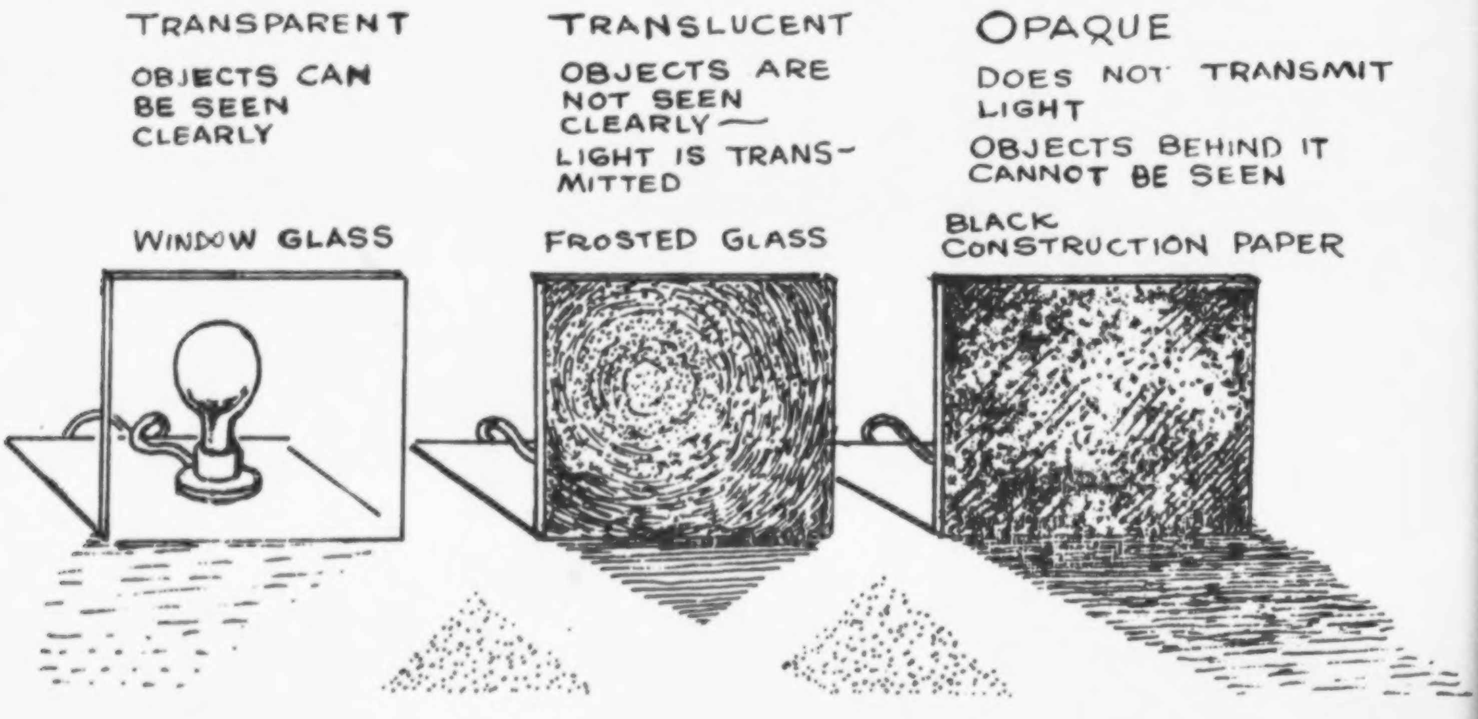
II. MATERIALS:

A. Window glass
B. Frosted glass
C. Wax paper
D. Sheet of notebook paper
E. Sheet of black construction paper
F. Clear plastic

III. PROCEDURE:

Hold each of the above materials toward the window or light source, one at a time.

1. Through which materials can you see objects clearly?
2. *Through which materials can you see light, yet not see objects clearly?*
3. Through which objects can you not see objects or light?


TRANSPARENT
OBJECTS CAN BE SEEN CLEARLY
TRANSLUCENT
OBJECTS ARE NOT SEEN CLEARLY — LIGHT IS TRANSMITTED
OPAQUE
DOES NOT TRANSMIT LIGHT
OBJECTS BEHIND IT CANNOT BE SEEN
WINDOW GLASS
FROSTED GLASS
BLACK CONSTRUCTION PAPER

IV. OBSERVATIONS:

A. Objects could be seen clearly through the window glass and clear plastic.

B. Light, but not objects, could be seen through the frosted glass, wax paper, and notebook paper. The notebook paper did not allow as much light to pass through as the frosted glass and the wax paper.

C. The black construction did not allow any light to pass through and you could not see objects through it.

V. CONCLUSION:

A. TRANSPARENT: transmitting light rays so that objects on the other side can be clearly seen---capable of being seen through.

The window glass and the clear plastic was transparent.

B. TRANSLUCENT: transmitting but diffusing light so that objects on the other side cannot be seen clearly.

1. The frosted glass, wax paper and notebook paper are translucent.

2. Since these materials did not all transmitt light at the same rate, we can safely say there are different rates or degrees of translucence.

C. OPAQUE: does not permit the transmission of light.

Since the black construction did not permit the passage of any light, it is opaque.

LIGHT

I. **OBJECTIVE:** Two ways to demonstrate refraction

II. **MATERIALS:**

- A. Pencil
- B. Two coins
- C. One beaker or clear drinking glass
- D. Two small crucibles or other shallow dishes
- E. Water

III. **PROCEDURE:**

- A. Place a coin in the bottom of each crucible.

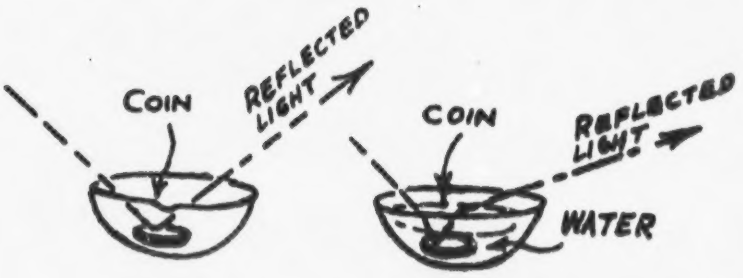
- B. Have a student back off just far enough so that both coins are hidden by the rim.

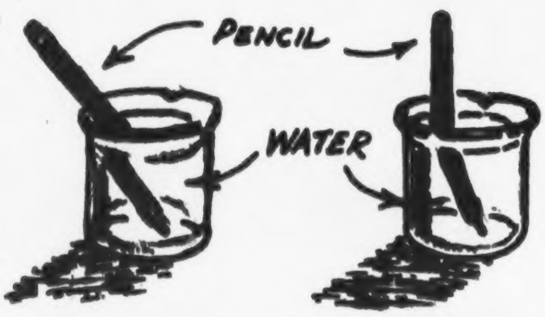
- C. Now add water to one crucible until almost full.

- D. Have student explain what he now sees.

- E. Fill the beaker with water and place pencil as illustrated.

- F. Observe pencil at various angles at various distances.





IV. **OBSERVATION:**

- A. The coin in the one crucible came into view as the water was added; the other coin still could not be seen.

- B. Depending upon the angle from which view, the pencil appeared to be "split" or "bent".

V. CONCLUSION:

A. The light reflected from the coin is bent (refracted) as it passes through the water.

B. The pencil appears to "bend" or "split" due to the refraction of the light as the light passes through the water.

C. The "bending" of the light rays is called refraction.

D. Light rays are refracted when they pass through a medium of one density and to a medium of another density.

LIGHT

I. OBJECTIVE: To demonstrate that the angle at which light rays enter a substance affects the refraction.

II. MATERIALS:

- A. Slide projector
- B. Aluminum foil
- C. Small aquarium
- D. Water
- E. Chaulk dust
- F. Eosin dye or a few drops of milk

III. PROCEDURE:

A. Cut a narrow slit in the aluminum foil and fasten the foil over the projector lens so that the slit is horizontal.

B. Fill the aquarium about half-full of water and dissolve a small amount of eosin dye in the water. (A few drops of milk will do.)

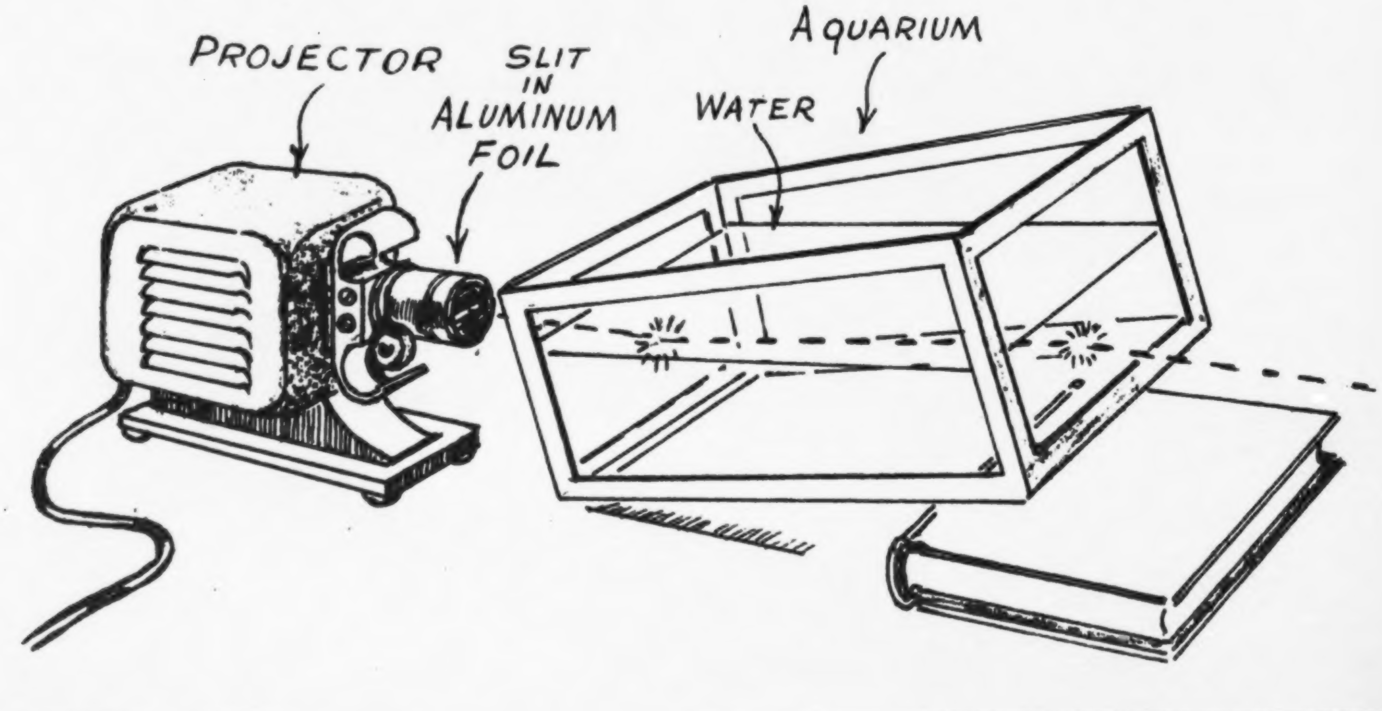
C. Darken the room.

D. Shine the beam of light through the aquarium so that it enters below the water level. Make certain that the aquarium is level.

E. Strike some blackboard erasers together on each side of the aquarium so that the beam of light can be seen through the chalk dust.

F. Tip the aquarium away from the projector, making certain that the beam of light enters below the water level.

G. Tip the aquarium towards the projector.



IV. OBSERVATION:

A. The beam of light passed straight through the water with no refraction when the aquarium was level.

B. The beam of light was refracted upwards when the aquarium was tilted away from the projector.

C. The beam of light was refracted downward when the aquarium was tilted toward the projector.

D. The greater the angle the aquarium was tipped, the greater the angle of refraction.

V. CONCLUSIONS:

The angle and direction that light rays are refracted by water is dependent upon the angle and direction at which the rays enter the water.

LIGHT

I. OBJECTIVE: To demonstrate and explain an optical illusion.

II. MATERIALS:

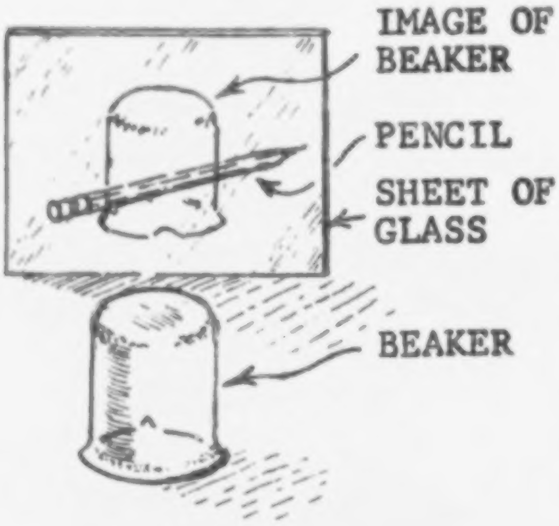
- A. Sheet of clear glass
- B. Beaker, flask or clear water glass
- C. Pencil

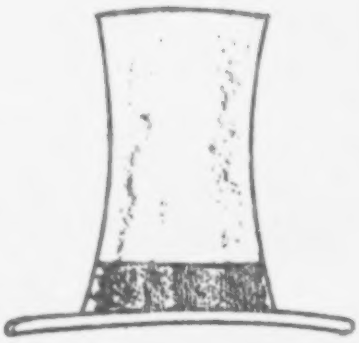
III. PROCEDURE:

A. Support the clear glass in a vertical position as illustrated.

B. Place the pencil on the table top about ten inches behind the glass.

C. Place the beaker in front of the clear glass so that the image of the tumbler is over the pencil.





IS THE BRIM OF THE HAT WIDER THAN THE HAT IS TALL?

IV. OBSERVATIONS:

A. The pencil appears to penetrate and go through the beaker.

B. The beaker is the same distance in front of the mirror as the image appears behind the mirror.

C. As the light reaching the beaker was blocked off, the image of the beaker disappeared.

V. CONCLUSION:

A. An optical illusion is an unreal, deceptive or misleading image to which the eye responds-----a false response to optical stimuli. The objects are real but they do not exist as they appear to the eye.

It can be caused by reflected or refracted light, by a series of lines or designs, etc.

B. A mirage is an optical illusion caused by the reflection of light through layers of air, of different temperatures and densities, causing distant objects to appear very near and often upside down-------The object from which the mirage originates is real, it just appears to be closer than it actually is.

C. EXAMPLES:

1. Moving pictures (Examine a strip of movie film. It is a sequence of differing still pictures.)

2. Magical tricks (Slight of hand by the magician)

LIGHT

I. OBJECTIVE: To demonstrate that the color of an object is determined by the colors of the light it reflects and absorbs.

II. MATERIALS:

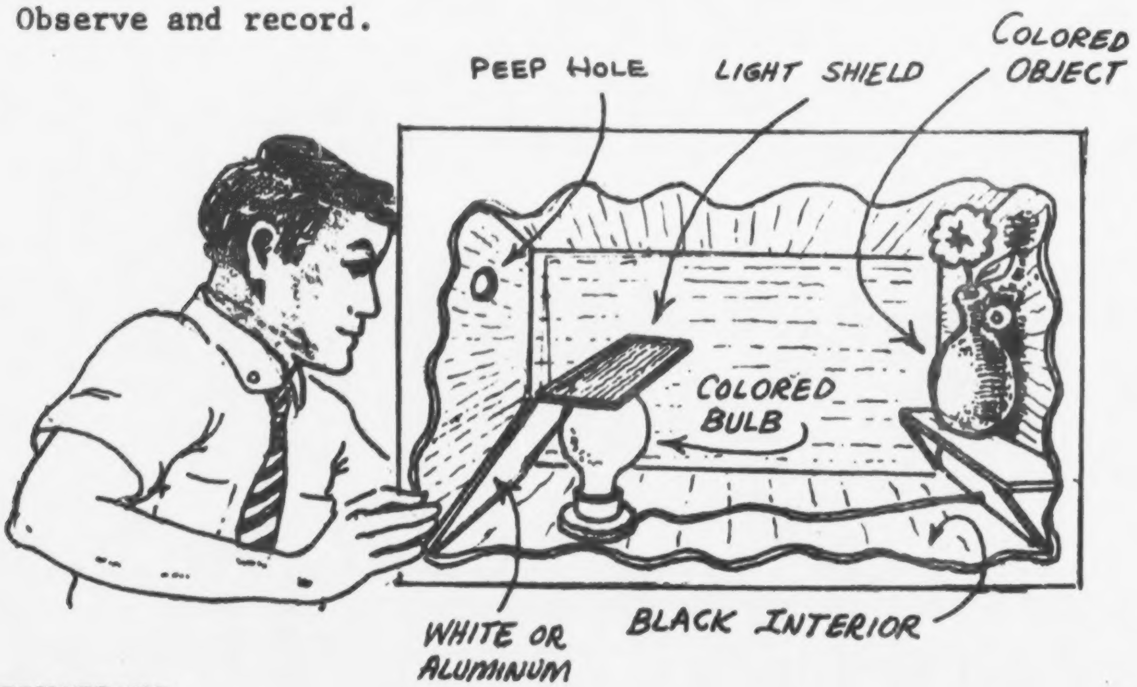
A. Wooden or cardboard box
B. Light socket
C. Various colored bulbs
D. Various colored objects

III. PROCEDURES:

A. Assemble apparatus as shown, colored objects through the peep hole.

B. View each colored object under each different color light.

C. Observe and record.


PEEP HOLE
LIGHT SHIELD
COLORED OBJECT
COLORED BULB
WHITE OR ALUMINUM
BLACK INTERIOR

IV. OBSERVATIONS:

Color of Light Bulb	Color of Object	Color Seen By the Eye
white	green	green
blue	red	black
red	green	black
yellow	white	yellow
green	black	black

V. CONCLUSION:

A. The colors we see depend upon the colors that are reflected, absorbed, or both.

B. Objects that appear white have reflected all the colors of the spectrum.

C. Objects that appear black have absorbed all the colors of the spectrum.

D. Objects that appear to be one of the colors of the spectrum have reflected that color only and absorbed all the other colors.

E. Objects that appear to be a color other than one of the colors of the spectrum, have reflected two or more colors and absorbed the others.

LIGHT

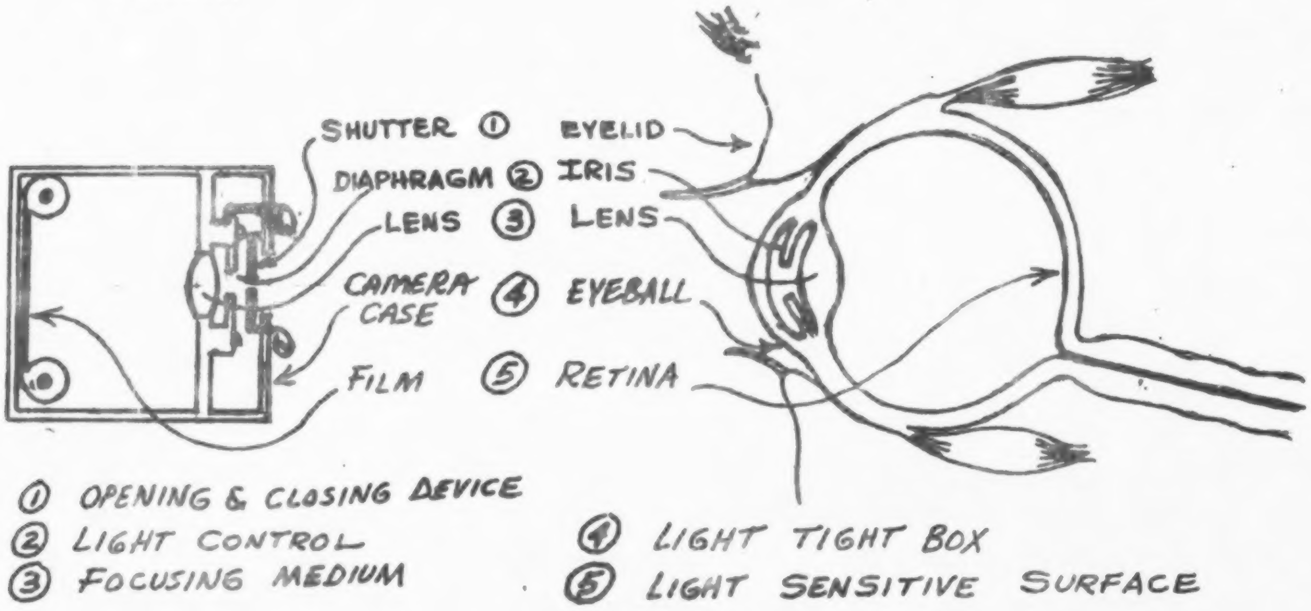
I. **OBJECTIVE:** To show how the camera is like the eye

II. **MATERIALS:**

A. Large diagram showing the parts of the eye and comparable parts in the camera

B. Dissectible model of the eye, if possible

C. An old inoperative camera with the parts that are shown in the drawing


SHUTTER ① EYELID
DIAPHRAGM ② IRIS
LENS ③ LENS
CAMERA CASE ④ EYEBALL
FILM ⑤ RETINA
① OPENING & CLOSING DEVICE
② LIGHT CONTROL
③ FOCUSING MEDIUM
④ LIGHT TIGHT BOX
⑤ LIGHT SENSITIVE SURFACE

III. **ADDITIONAL INFORMATION:**

A. Your brain tells you instantly what your eye is seeing----the viewer finder tells you what the camera is seeing.

B. On many cameras, a bellows replaces the light-tight box allowing for greater compactness.

C. The film is coated on one side with a light-sensitive substance known as an emulsion. The key ingredient of the emulsion is a compound in crystalline form called silver bromide.

D. When you flash an image on this emulsion by allowing the shutter to open and close, a chemical change takes place, but it is not noticeable to the eye until further chemical changes take place by placing the film in a solution known as the developer. Once the image becomes visible, the film is placed in another solution known as the fixer which prevents the picture from fading out---it makes the picture permanent.

E. The developed and fixed film is a negative ---- it shows the light and dark areas in the reverse of what they are on the finished print.

F. You get the finished print or picture by placing the negative in contact with a sensitized photographic paper and exposing to light for a given period of time, after which the paper goes through solutions of developer and fixer, similar to the process used in developing the films. You then have a positive, a print or a picture.

G. In the case of color photography, the process is more complicated, the film having emulsions that are sensitive to the various colors. The processing is also more involved and includes many solutions and second exposure to light of the film.

LIGHT

I. OBJECTIVE: To demonstrate that light rays travel in a straight line. To demonstrate how a pinhole camera works.

II. MATERIALS:

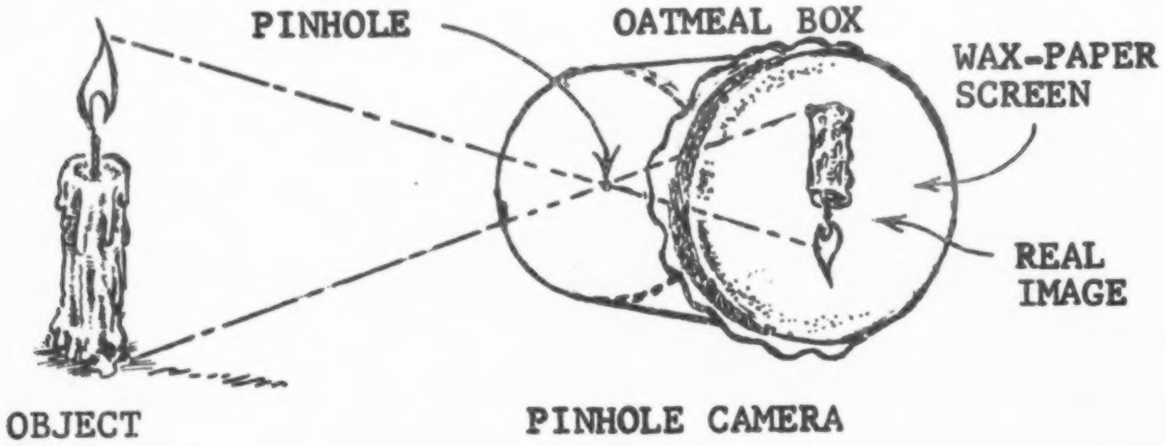
- A. Empty oatmeal box
- B. Wax-paper
- C. Rubber band
- D. Lighted candle

III. PROCEDURES:

A. Poke a pinhole through the center of the bottom of the oatmeal box.

B. Make a screen of wax-paper and fasten over the open end with the rubber band.

C. Aim the pinhole end of the cereal box at the lighted candle and observe the wax-paper screen.



IV. OBSERVATION:

The image of the candle appeared on the wax-paper screen in an inverted position.

V. CONCLUSION:

A. Light rays from the top of the candle have traveled in a straight line as shown and have hit the bottom part of the screen.

B. Light rays from the bottom of the candle have traveled in a straight line as shown and have hit the top part of the screen.

C. The apparatus we have constructed is called a pinhole camera. In order for this camera to operate, we would have to add a shutter over the pinhole and make arrangements for the film at the end where the wax-paper screen is located.

LIGHT

I. OBJECTIVE: To make a spectroscope.

II. MATERIALS:

- A. 1 small can 4" high and 2 1/8" in diameter
- B. Transparent diffraction grating 1" X 1"
- C. Masking tape
- D. Screwdriver
- E. Hammer
- F. Punch

III. PROCEDURE:

A. Cut both ends of can off as shown in illustration.

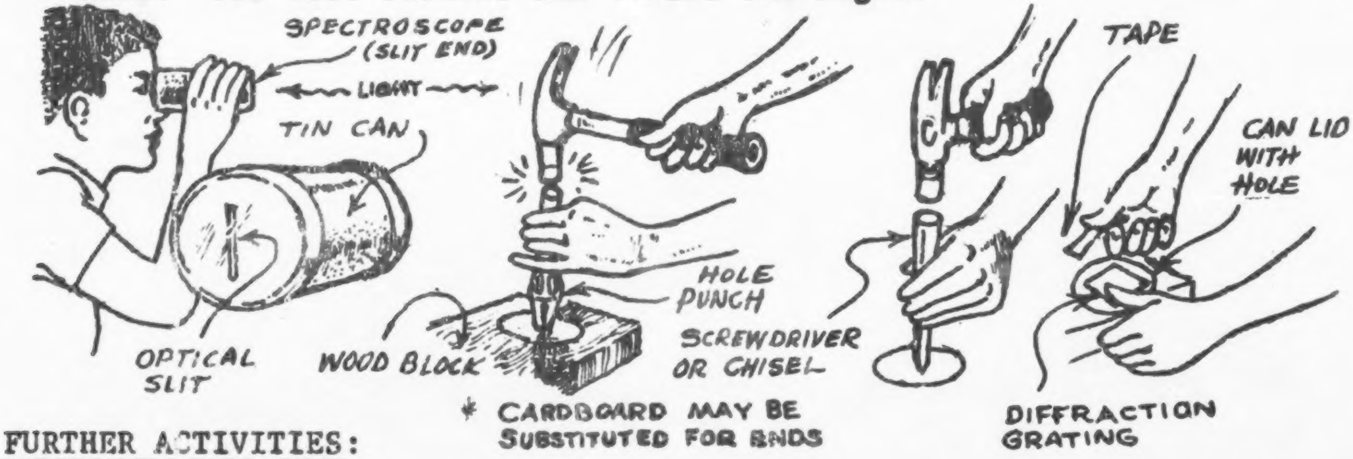
B. In one end of can cut small slit about 1 1/4" long and about 1/8" wide. Place lid on block of wood and use screwdriver and hammer out small slit.

C. In other end of can use punch and hammer to punch a small hole about 1/4" in diameter. This can vary in size.

D. Place diffraction grating on inside of lid with the 1/4" hole and tape on. Do not tape over small hole. Then tape on can cylinder.

E. Tape the other end with the slit - on the other end of cylinder. Note Illustration Below.

F. Observe through the end of the spectroscope with the small 1/4" hole. For best results aim toward the light.



* CARDBOARD MAY BE SUBSTITUTED FOR ENDS

IV. FURTHER ACTIVITIES:

A. Have students draw the rainbow and color in its various colors.

B. For kindergarten and first graders: Have them observe the spectra and select the proper colors from assortment of colors.

C. For upper grades study the diffraction of light waves.

D. One easy way the student may remember the order of colors of the spectra is from the name of the little boy: ROY G BIV --- R-Red O-Orange Y-Yellow G-Green B-Blue I-Indigo V-Violet

LIGHT

I. OBJECTIVE: To construct a periscope and explain how it works.

II. MATERIALS:

A. Mailing tube about two inches in diameter, two or more feet long.
B. Two plane (flat) mirrors, two inches by two and one half inches.

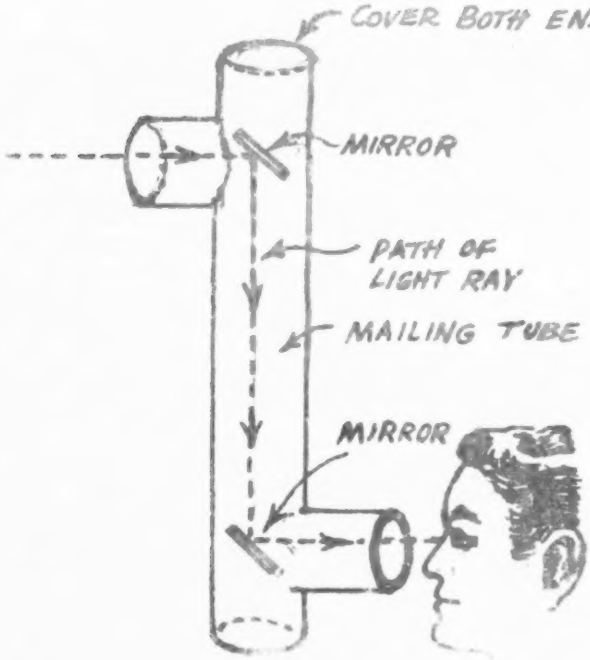
III. PROCEDURE:

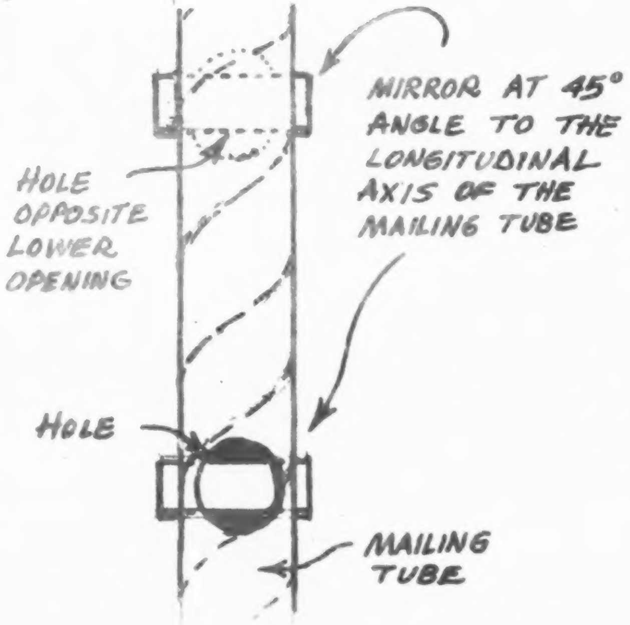
A. Cut 45 degree angle slots to accomodate the two mirrors as illustrated.

B. Allow the mirrors to extend over the outside edges to hold them in place.

C. Cut eye hole and light hole as indicated.

D. When periscope is completely assembled, extend light hole past corner and observe through the eye hole.


COVER BOTH ENDS
MIRROR
PATH OF LIGHT RAY
MAILING TUBE
MIRROR


MIRROR AT 45° ANGLE TO THE LONGITUDINAL AXIS OF THE MAILING TUBE
HOLE OPPOSITE LOWER OPENING
HOLE
MAILING TUBE

IV. OBSERVATIONS:

Objects around the corner could be seen without the observer going around the corner himself.

V. CONCLUSION:

The light rays reflected from an object enter the light hole, strike the first mirror, are reflected 90 degrees to the second mirror and another 90 degrees to the eye.

ADDITIONAL ACTIVITIES:

A. A slightly smaller and short tube could be added to the light and eye holes to eliminate some of the excess light.

B. If the top mirror is angled 45 degrees in the opposite direction from the bottom mirror, the periscope then can be used to see objects behind the viewer.

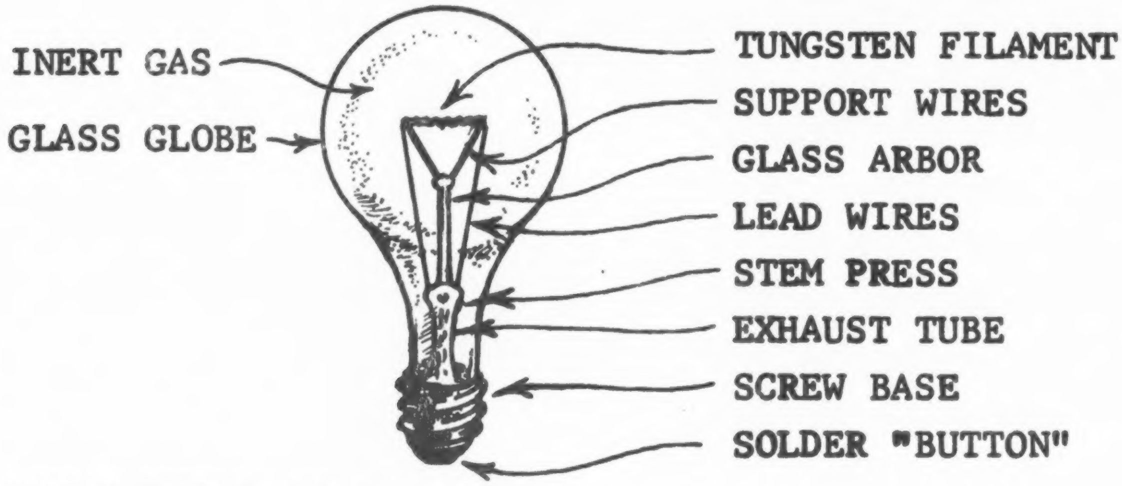
LIGHT

I. OBJECTIVE: The incandescent lamp and how it works.

II. MATERIALS:

A. Large drawing showing the parts of the incandescent lamp.

B. Dissected incandescent lamp with parts mounted and labeled.


INERT GAS
GLASS GLOBE
TUNGSTEN FILAMENT
SUPPORT WIRES
GLASS ARBOR
LEAD WIRES
STEM PRESS
EXHAUST TUBE
SCREW BASE
SOLDER "BUTTON"

III. THE INCANDESCENT LAMP:

A. Invented in 1879 by Thomas A. Edison.

B. He first used carbonized thread, then carbonized cellulose for the filament.

C. Later, tungsten wire replaced the carbonized material, the tungsten wire was coiled like a spring for even greater brightness.

D. Electric current has a heating effect as it passes through a conductor. The better the conductor and the greater its size, the less heat produced.

E. In the case of the incandescent lamp, the filament is high resistant tungsten metal that reaches a white heat or "incandescence" at 2800 degrees C.

F. At this temperature the metal would rapidly burn away if it were not enclosed in globe from which the air was removed and replaced with an inert gas such as argon or nitrogen.

G. The efficiency of an incandescent lamp is small because a large amount of the electrical is changed to heat energy, rather than to light.

H. The glass globe was first frosted in 1924 to reduce the glare by diffusing the light.

IV. HOW THE INCANDESCENT LAMP WORKS:

A. Like all electrical appliances, the light bulb must also have two contacts or wires entering, one positive and one negative.

B. The positive contact is the solder "button" on the very bottom of the base, to which one lead wire is connected and completely insulated from the base.

C. The second lead wire is connected to the inside surface of the base as indicated.

D. The lead wires carry the current up to and through the tungsten filament.

E. The tungsten filament, being a high resistant metal (a poor conductor) glows white hot and becomes incandescent.

F. Incandescent means glowing with intense heat and giving off light.

G. The arbor and support wires support the lead wires and the filament.

H. The stem press contains the exhaust tube through which the air was removed and the inert gas was added.

I. The screw base is a convenient method of replacing burned out bulbs.

J. When a bulb is "burned out," it means the filament or one of the lead wires has broken or burned off.

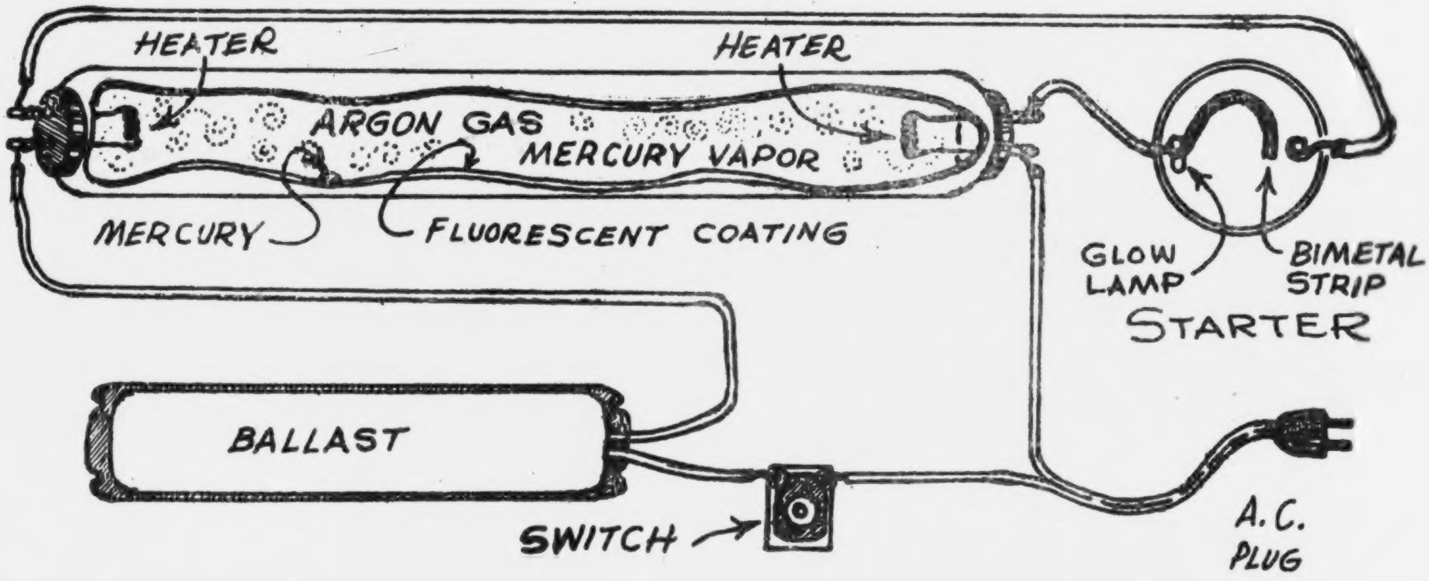
LIGHT

I. **OBJECTIVE:** To explain how the fluorescent light works.

II. **MATERIALS:**

A. Large drawing showing the parts of the fluorescent tube and lamp.

B. A fluorescent light with all parts mounted so that they can be seen.



III. **HOW THE FLUORESCENT LIGHT WORKS:**

A. When the fluorescent lamp is turned on, a glow lamp in the starter causes the bimetal strip to make momentary contact.

B. This allows the cathodes (heater) to receive the full current and become incandescent, (white hot). The cathodes are coiled tungsten coated with an active salt.

C. The Argon or Krypton gas in the air tight, low pressure tube becomes ionized and acts as a conducting medium.

D. The heat causes the drop of mercury to vaporize, creating a path of low resistance between the two main electrodes.

E. The electrons emitted by the hot filaments strike the mercury atoms creating high energy ultraviolet waves.

F. These high energy ultraviolet waves strike the fluorescent coating on the inside of the tube causing it to glow and give off light. The color of the light is determined by the type of coating. (calcium tungstate, zinc sulphide or zinc silicate)

G. Once the arc is established through the mercury vapor, which is lower resistance, the starter becomes inactive and the lamp will continue to function even though the starter is removed.

H. The cathodes (heaters) continue to glow at white heat due to the action of the mercury ions.

I. The ballast (transformer) steps up the voltage to the proper operating level of the fluorescent lamp.

IV. ADDITIONAL INFORMATION:

A. The fluorescent lamp was introduced in 1938.

B. The fluorescent lamp produces from two to four times as much light per watt as the ordinary incandescent lamp used in homes and businesses. This means it costs two to four times more for electricity for the same amount of light from an incandescent bulb as from a fluorescent lamp.

C. Fluorescent lamps give off less heat than incandescent lamps.

D. Shadows can be overcome with the long tube arrangement.

E. The general purpose incandescent lamp used in homes gives 16 to 18 lumens per watt.

1. A fluorescent lamp gives 60 lumens per watt.
2. A lumen is the amount of light on a surface one foot square and one foot from a standard candle.

MAGNETISM

CONTENT:

INTRODUCTION

VOCABULARY

CONCEPTS

To explain the theory of magnetism.

To explain the types of magnets and their care.

To show the attracting and repelling action of magnets.

To show the lines of force in the magnetic field.

To show what materials are attracted by magnets.

To make a magnetizer.

To make an electro-magnet and explain how it works.

To make a compass from a bar magnet.

To make a floating needle compass.

To show the earth's magnetic field.

MAGNETISM

I. INTRODUCTION:

A. Magnet: Any piece of metal, iron or steel, that has the property of attracting other iron or steel objects.

B. Natural magnet: A type of iron ore found in nature with properties of a magnet.

1. Magnetite: (Fe_3O_4) an important iron ore -- a magnetic iron oxide
2. Loadstone: (Fe_3O_4) (lodestone) --- a highly magnetic variety of magnetite.

C. Permanent Magnet: A piece of iron or steel or iron alloy in which magnetic properties have been artificially induced.

D. Magnetic: Having the properties of a magnet, capable of being magnetized, or capable of being attracted by a magnet.

E. Magnetize: To make into a magnet.

F. Magnetic field: That space around a magnet occupied by the magnetic lines of force ---- the space around the magnet in which the magnetic force is exerted.

G. Lines of Force: Lines in a magnetic field showing the direction of the force at any point.

H. Poles of a Magnet: The ends of a magnet ---- when allowed to swing freely, a bar magnet will point to the magnetic north and magnetic south poles of the earth.

MAGNETISM

I. OBJECTIVE: To explain the theory of magnetism.

II. MATERIALS:

A. Large illustrations as A and B
B. Strong magnet
C. Needle or nail
D. Iron filing

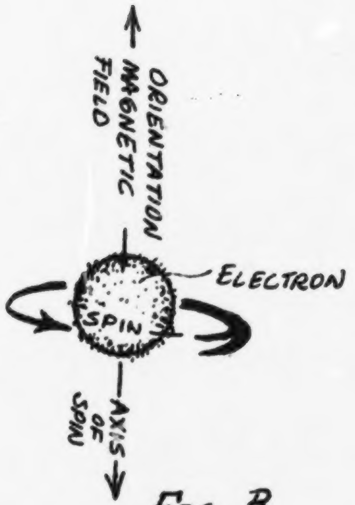
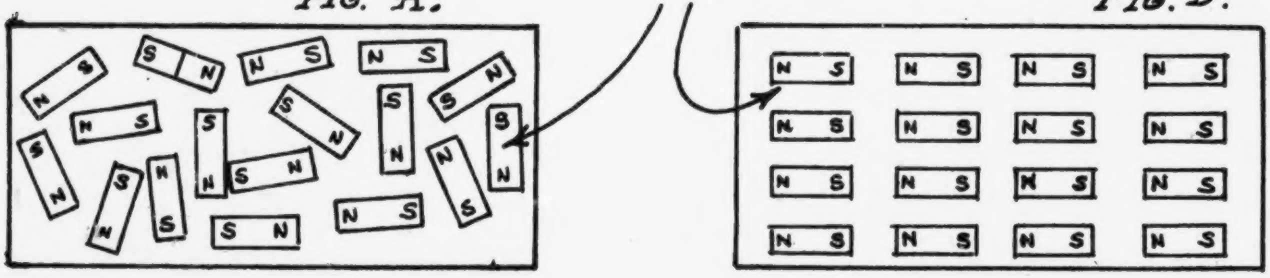


Fig. A. DOMAINS * *Fig. B.*



NON MAGNETIZED

MAGNETIZED

DOMAINS ARE CREATED BY THOUSANDS OF ATOMS HAVING ELECTRONS WITH PARALLEL SPIN · ELECTRON SPIN CREATES A TINY MAGNET

III. PROCEDURE:

A. Display illustration "A" explaining that in theory it is believed that each atom is a tiny magnet with a north and a south pole. In illustration "A" the arrangement of atoms is random, thus not magnetized.
B. Dip the non-magnetized needle or nail in the iron filings. The filings should not be attracted to the needle or nail. Atoms are as in "A".
C. Now stroke, (in one direction only) the needle or nail with a strong magnet. Explain that atoms now take an orderly or uniform arrangement as in "B", thus should become magnetized.
D. Check needle or nail again for magnetic properties by dipping into the iron filings.

IV. OBSERVATIONS:

A. The non-magnetized needle did not attract any of the filings.
B. When stroked in one direction with a strong magnet, the needle becomes magnetized and attracts the filings.

MAGNETISM

V. CONCLUSION:

A. The arrangement of the atoms in a piece of metal determines whether or not it is a magnet.

B. If the atoms are uniformly arranged, (lined up) in a piece of iron, the iron becomes a magnet. If they are not uniformly arranged, the iron is not a magnet.

C. Stroking a piece of iron with a magnet tends to cause the atoms to line up or become uniformly arranged, thus creating a magnet of the piece of iron.

MAGNETISM

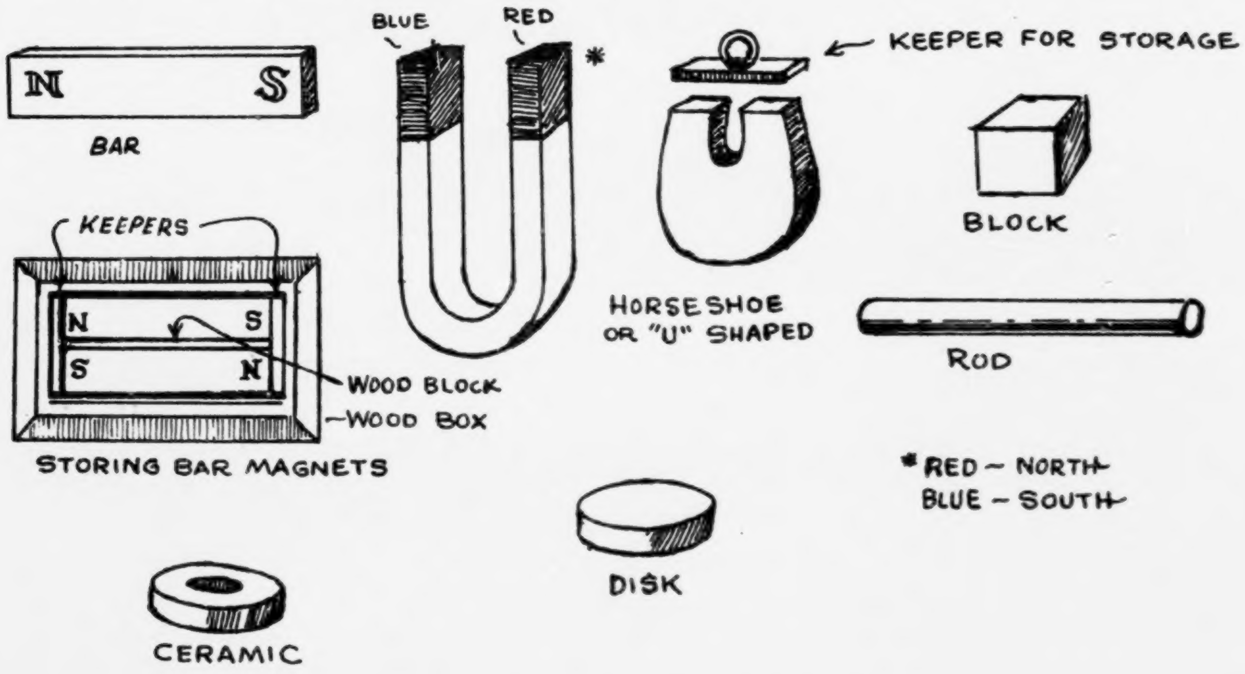
I. **OBJECTIVE:** Types of magnets and their care.

II. **MATERIALS:**

A. Various types of magnets --- horseshoe, bar, "U" shaped, etc.

III. **PROCEDURE:**

A. Display the various magnets as illustrated.


N
S
BAR
BLUE
RED
*
KEEPER FOR STORAGE
BLOCK
KEEPERS
N
S
S
N
WOOD BLOCK
WOOD BOX
STORING BAR MAGNETS
HORSESHOE
OR "U" SHAPED
ROD
*RED – NORTH
BLUE – SOUTH
DISK
CERAMIC

IV. **DISCUSSION:**

A. These are all permanent magnets, they are man-made.
B. They are called permanent because they hold their magnetism for a long period of time.
C. They can loose their magnetism by:
   (1) being dropped
   (2) being hammered
   (3) being exposed to intense heat
   (4) being improperly stored

V. **CONCLUSION:**

A. Permanent magnets are expensive and should be handled properly.

B. They should be stored with opposite poles together. (Bar magnets)

C. Horseshoe and "U" magnets should have an iron or steel "keeper" between the poles

MAGNETISM

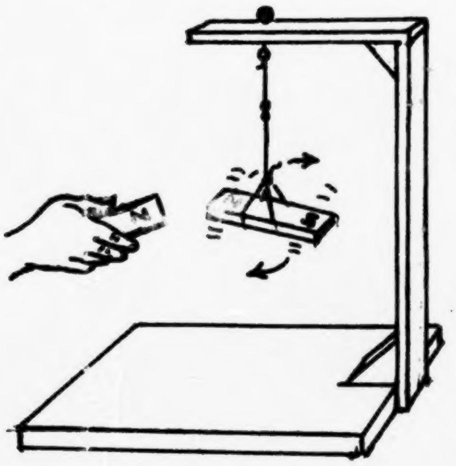
I. **OBJECTIVE**: To show the attracting and repelling action of magnets
To show the lines of force in the magnetic field

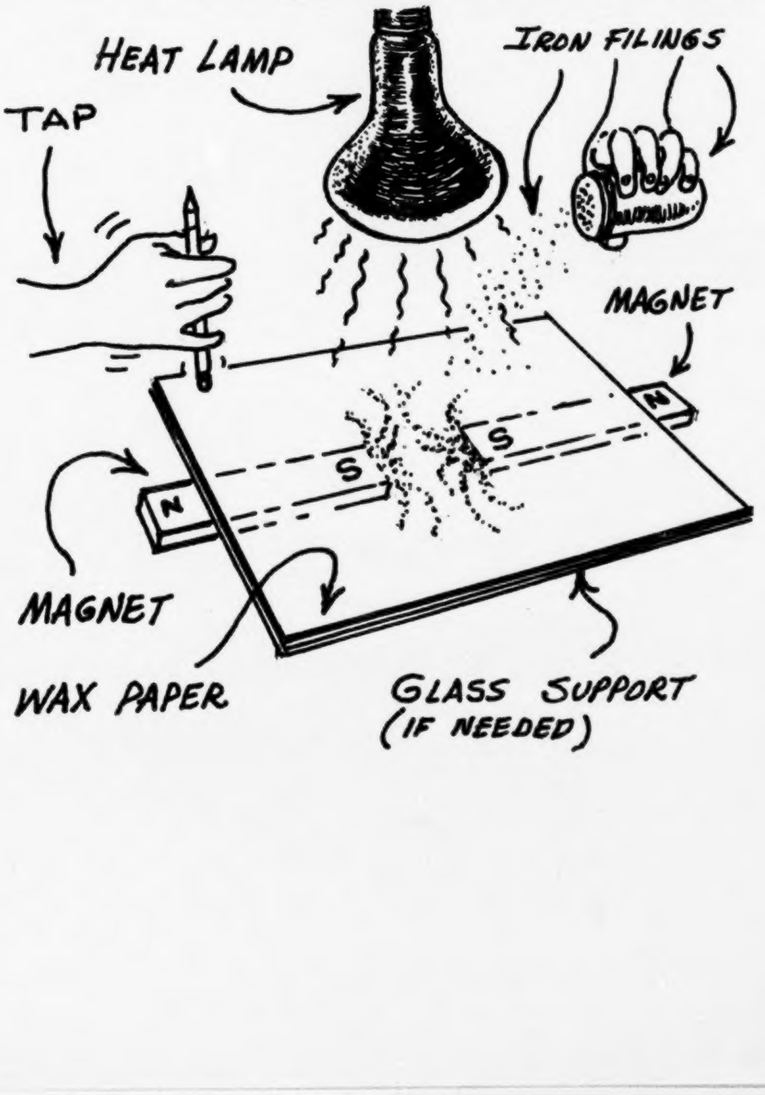
II. **MATERIALS**:

- A. 2 permanent bar magnets with poles labeled
- B. string
- C. iron filings
- D. wax paper
- E. heat lamp

III. **PROCEDURE**:

- A. Suspend one bar magnet from a non-magnetic support by the string as illustrated.
- B. Move the north pole of the second magnet slowly towards south pole of suspended magnet and observe
- C. Now slowly move north pole of second magnet towards north pole of suspended magnet and observe
- D. Slowly move south pole of second magnet towards south pole of suspended magnet and observe
- E. Place magnets under wax paper as illustrated, -- sprinkle some filings over poles of magnets, -- tap wax paper gently, -- now turn heat lamp on so that wax will melt, but being careful not to burn paper. Allow the wax paper to cool, then shake off excess filings. You now have a record of the magnetic field and the lines of force.





MAGNETISM

IV. OBSERVATIONS:

A. Like poles repelled each other --- unlike poles attracted each other.

B. The filings line up in a definite pattern when the paper was tapped. You could see the repelling and attracting action in the lines of force as represented by the arrangement of the iron filings.

V. CONCLUSION:

A. In magnets, like poles repel, ---- unlike poles attract.

B. The iron filings lined up along the invisible lines of force, showing the magnetic field and the arrangement of the lines of force under the different conditions.

MAGNETISM

I. OBJECTIVE: What materials are attracted by magnet?

II. MATERIALS:

A. Strong magnet
B. Steel
C. Iron
D. Copper Penny
E. Aluminum
F. American nickel
G. Canadian nickel
H. Glass
I. Wood
J. Paper
K. Cloth
L. Plastic
M. Lead
N. Brass
O. Zinc

III. PROCEDURE:

A. Attempt to attract the various materials with the magnet.
B. List those which can be attracted under the heading "magnetic" and those which cannot be attracted under the heading "non-magnetic".
C. Try any other materials, metals or non-metals that you might have handy.

IV. OBSERVATIONS:

A. Only the iron, the steel, and the Canadian Nickel were attracted.

B. The other substances were not attracted by the magnet.

V. CONCLUSION:

A. Only materials that contain a sufficient amount of iron, nickel, or cobalt are magnetic, -----can be attracted by a magnet.

MAGNETISM

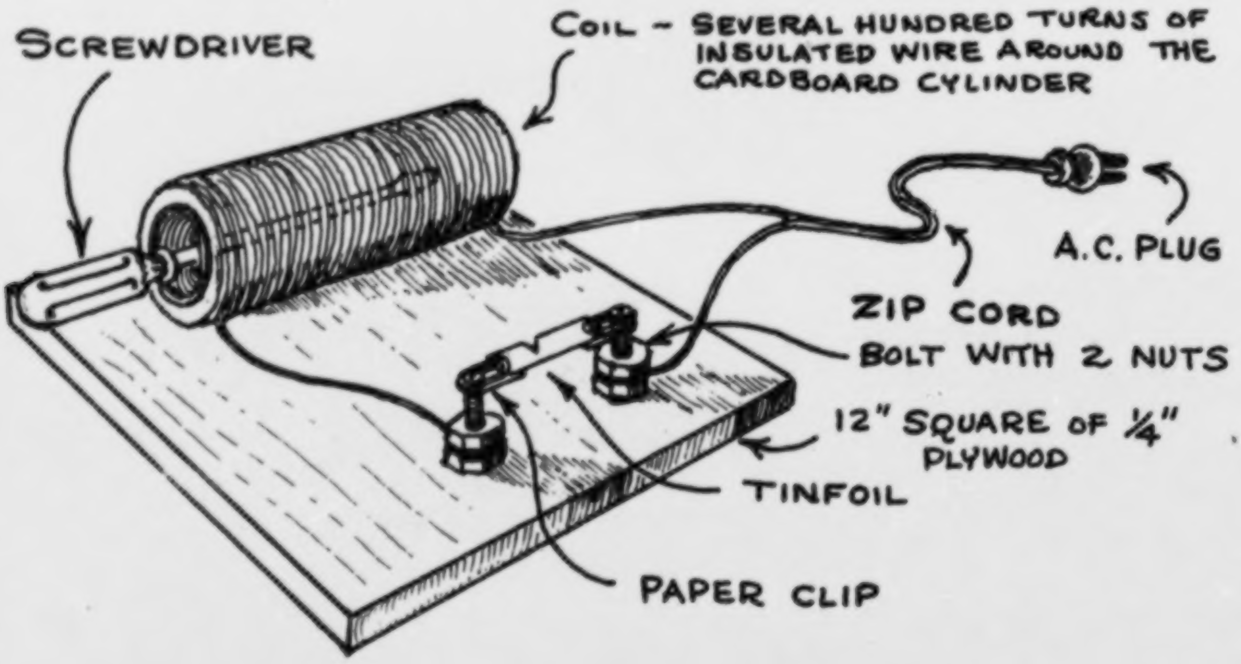
I. OBJECTIVE: To make a magnetizer.

II. MATERIALS:

A. Insulated wire
B. Cardboard cylinder
C. 2 bolts with 4 nuts
D. 1/4 inch plywood --- 12 inches square
E. Plug
F. Tin foil
G. Screwdriver, bolt, or other steel

III. PROCEDURE:

A. Set up equipment as illustrated.
B. Coil several hundred turns of the insulated wire around the cardboard cylinder, leaving a length of wire on each end.
C. Connect to the bolts and plug as illustrated.
D. Fasten fuse of tin foil to bolts as illustrated.
E. Insert screwdriver or other piece of steel in cylinder.
F. NOW, and only now, insert plug into wall outlet.
G. After fuse has blown, remove plug from outlet.
H. Remove screwdriver from cylinder and test for magnetic properties.


SCREWDRIVER
COIL - SEVERAL HUNDRED TURNS OF INSULATED WIRE AROUND THE CARDBOARD CYLINDER
A.C. PLUG
ZIP CORD
BOLT WITH 2 NUTS
12" SQUARE OF ¼" PLYWOOD
TINFOIL
PAPER CLIP

MAGNETISM

IV. OBSERVATIONS:

A. The fuse "blew" and the screwdriver became magnetized.

V. CONCLUSION:

A. The sudden surge of A.C. (alternating current) electricity through the coil affects the arrangements of the molecules or atoms in the steel, causing the screwdriver to become magnetized.

B. It is not known definitely how this is caused ---- see theory of magnetism demonstration and drawings.

MAGNETISM

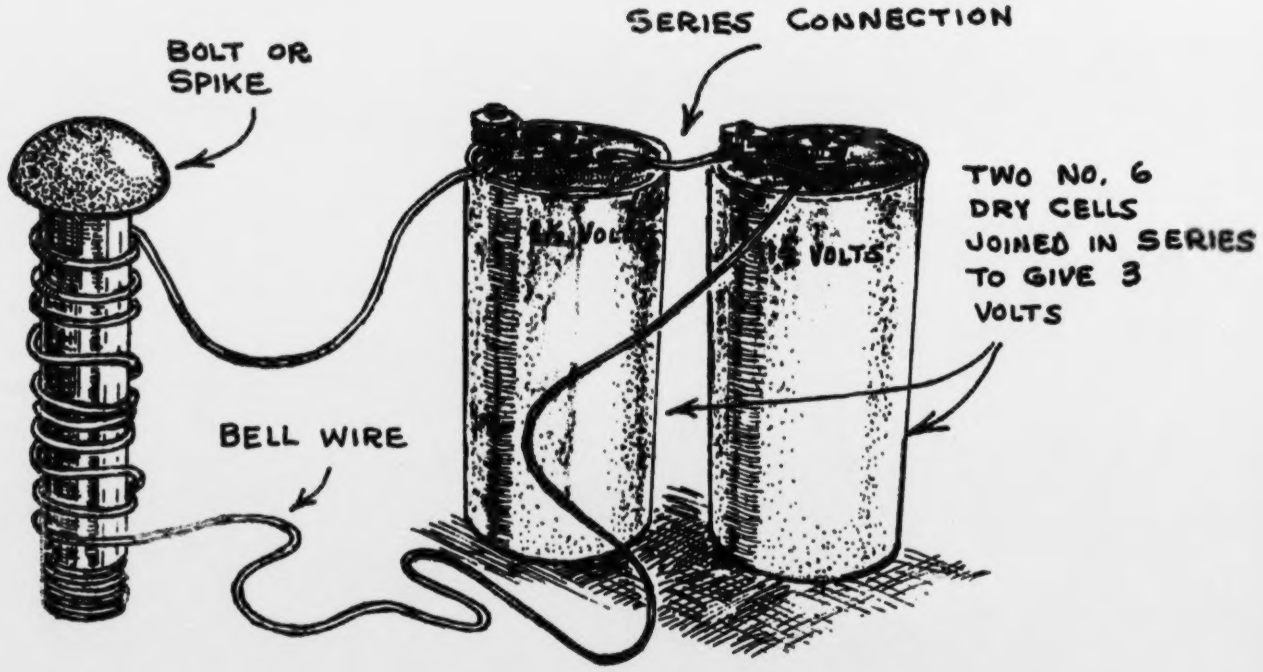
I. OBJECTIVE: Making an electro-magnet and explaining how it works.

II. MATERIALS:

A. Bell wire
B. 2 dry cells or a D. C. power source
C. Bolt or spike
D. Paper clips

III. PROCEDURE:

A. Coil 10 turns of the wire around the nail or bolt and connect to one dry cell as illustrated. See how many paper clips you can pick up with this arrangement.
B. Increase the number of turns to 20, 40, and 60, record the number of clips picked up.
C. Repeat A and B, joining the two dry cells in series or by indreasing voltage on D. C. power source.
D. Repeat A, B, and C, this time using a larger bolt or nail


SERIES CONNECTION
BOLT OR SPIKE
1½ VOL
1½ VOLTS
TWO NO. 6 DRY CELLS JOINED IN SERIES TO GIVE 3 VOLTS
BELL WIRE

MAGNETISM

IV. OBSERVATIONS:

A. As the number of windings were increased, the strength of the magnet was increased.

B. As the voltage was increased, the strength of the magnet was increased.

V. CONCLUSION:

A. Electro-magnets can be made stronger by increasing the number of windings around the core.

B. Electro-magnets can be made stronger by increasing the voltage.

C. Electro-magnets can be made stronger by increasing the size of the soft core along with increasing the voltage and the number of turns.

MAGNETISM

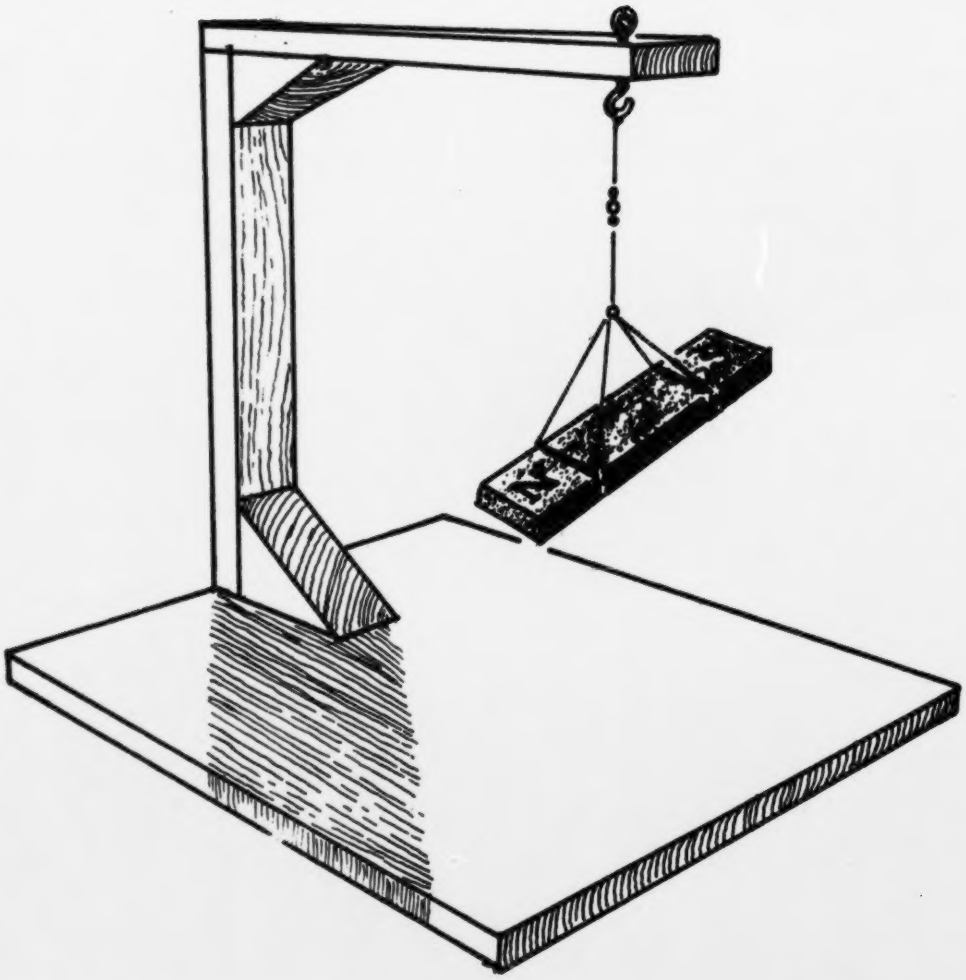
I. **OBJECTIVE:** To make a compass from a bar magnet.

II. **MATERIALS:**

- A. Bar magnet
- B. String
- C. Non-magnetic support

III. **PROCEDURE:**

- A. Set up equipment as illustrated
- B. Allow magnet to swing freely



MAGNETISM

IV. OBSERVATIONS:

A. When the bar magnet was suspended so that it could swing freely, it came to rest pointing to the north and to the south --- the north pole pointed to the earth's north magnetic pole and the south pole pointed to the earth's south magnetic pole.

V. CONCLUSION:

A. A compass is actually a free swinging bar magnet.

B. The poles of a magnet are marked according to the direction they point.

C. The north pole is actually a north "seeking" pole, ---- that is, it is attracted to the magnetic north pole of the earth.

MAGNETISM

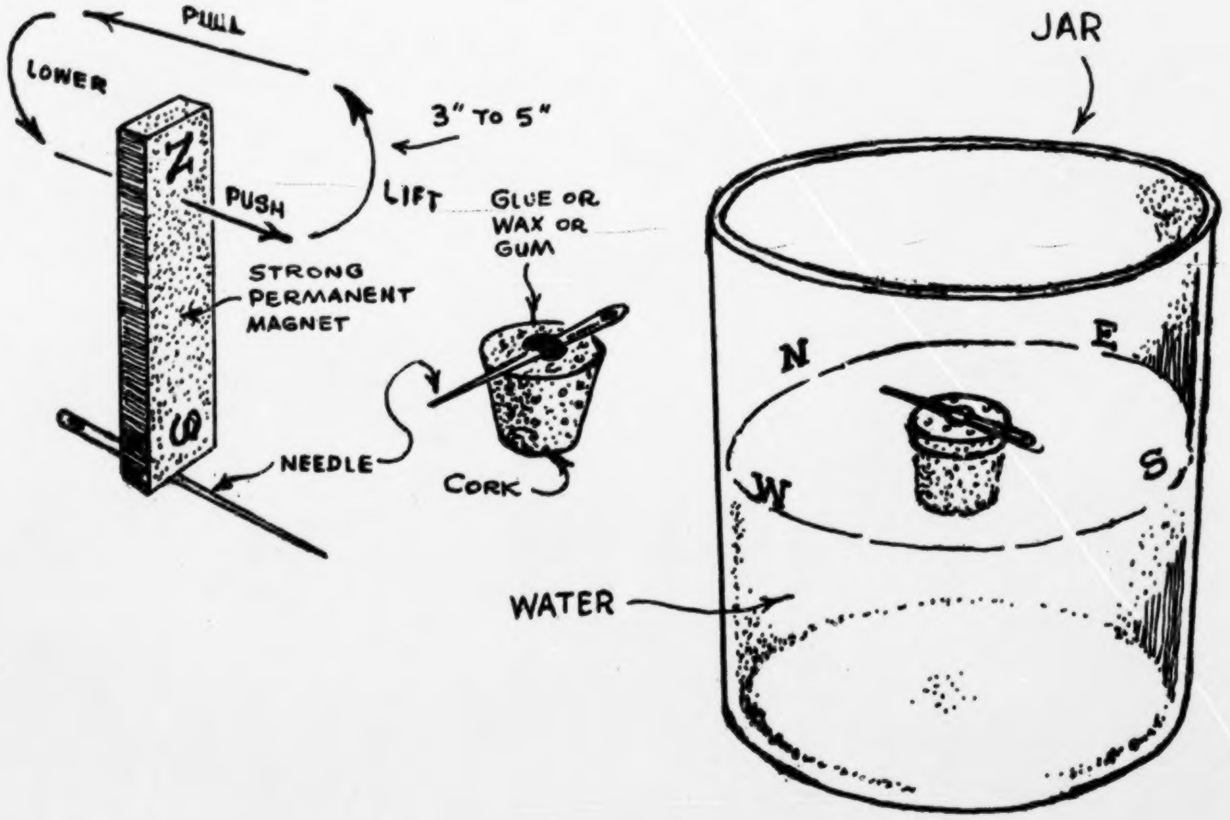
I. **OBJECTIVE:** Making a floating needle compass.

II. **MATERIALS:**

- A. Needle
- B. Peanut butter jar
- C. Cork from soda pop bottle
- D. Strong magnet
- E. Water
- F. Glue
- G. Tape

III. **PROCEDURE:**

- A. Magnetize needle by stroking in one direction with a magnet as shown
- B. Glue magnetized needle to the cork from pop bottle cap
- C. Float cork and needle as illustrated
- D. Lable jar N - E - S - W as illustrated


PULL
LOWER
3" TO 5"
LIFT
PUSH
N
S
STRONG PERMANENT MAGNET
NEEDLE
GLUE OR WAX OR GUM
CORK
JAR
N
E
S
W
WATER

MAGNETISM

IV. OBSERVATION:

A. The floating needle lined up in a north-south direction.

V. CONCLUSION:

A. NEEDLE BECAME MAGNETIZED WHEN STROKED WITH THE MAGNET.

B. The floating magnetized needle became a compass, lining up in a north-south direction.

MAGNETISM

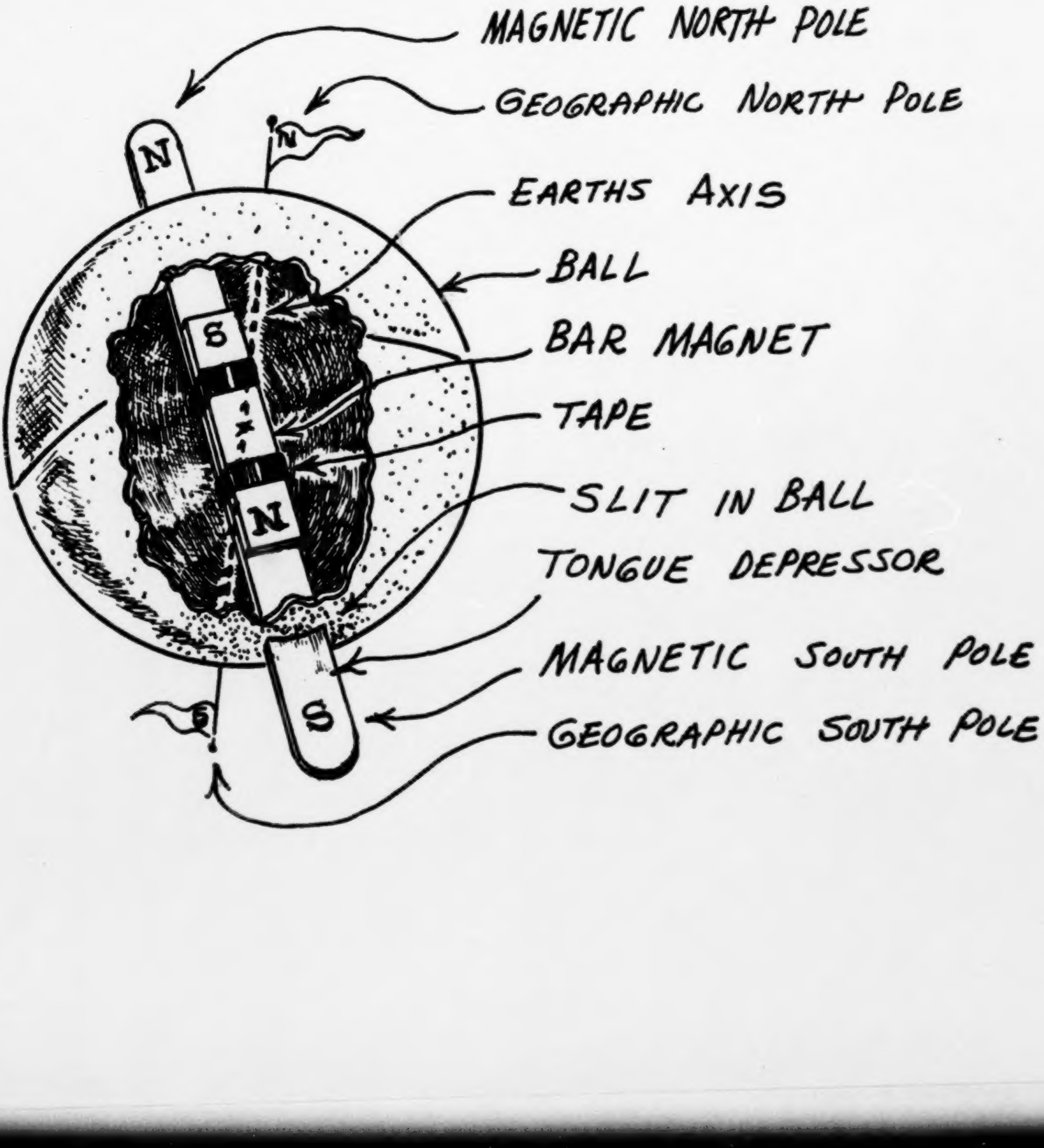
I. OBJECTIVE: The earth's magnetic field.

II. MATERIALS:

- A. Rubber ball, 4 to 6 inches in diameter
- B. Bar magnet
- C. Wooden tongue depressor
- D. 2 small paper flags (These can be made using toothpicks for poles)
- E. Compass
- F. Masking tape

III. PROCEDURE:

- A. Tape the magnet to the tongue depressor as illustrated.
- B. Insert inside rubber ball, making certain that the south pole of the magnet is towards the north magnetic pole of the ball (earth) DO NOT let the children know this at this time.
- C. Place the flags over the geographic north and south poles.
- D. Bring the compass near the north magnetic pole --- which end of the compass needle points to the north magnetic pole? Which end points towards the south magnetic pole?
- E. NOW allow students to see magnet's position in the earth (ball).


MAGNETIC NORTH POLE
GEOGRAPHIC NORTH POLE
N
N
EARTHS AXIS
BALL
BAR MAGNET
S
TAPE
N
SLIT IN BALL
TONGUE DEPRESSOR
MAGNETIC SOUTH POLE
S
S
GEOGRAPHIC SOUTH POLE

MAGNETISM

IV. OBSERVATIONS:

A. The north end of the compass points to the magnetic north pole.

B. The south end of the compass points to the magnetic south pole.

C. The north end of the compass needle points to the magnetic north pole because it is a "north-seeking needle"----

V. CONCLUSION:

A. When man first made and used a compass, he called the end that pointed north --- the north-seeking needle and gave it the label "N" or north --- thus the north seeking pole is actually a south pole which is attracted to the earth's magnetic north pole.

ELECTRICITY

CONTENT:

INTRODUCTION

VOCABULARY

CONCEPTS

To construct an electric panel which will show:

Overloaded circuit] and the hazards they present
Short circuit]
Safety devices
Parallel wiring of lights
Series wiring of lights
What a switch does to a circuit

To show the main parts of an electric circuit.

To demonstrate and explain parallel and series wiring of lights.

To demonstrate and explain a short circuit.

To show an overload on a circuit and how a safety device protects the circuit.

To explain how to cut away dry cell batteries and how these cut-a-way batteries can be utilized in the classroom.

To explain how to cut away the various sizes of dry cells.

To explain the operation of a dry cell and show the various parts.

To show how to cut away a 6 or 12 volt storage battery.

To explain the operation of a storage battery (wet battery) and show the various parts.

ELECTRICITY
(Continued)

To show the difference between a cell and a battery.

To show series joining of cells.

To show parallel joining of cells.

To construct and study the characteristics of a simple wet cell (voltiac cell).

To show how current electricity is produced by induction.

To show the main parts of a generator.

To show the difference between an A.C. and D.C. generator.

To construct a simple A.C. generator.

To explain and show effects of A.C. electricity.

ELECTRICITY

I. INTRODUCTION:

A. Current Electricity: is the movement of electrons through a conductor.

B. Two types of Current Electricity:

1. Alternating Current:
    - a. This is the type of electricity used almost exclusively by industry, business, and for home use.
    - b. It can be transmitted over long distance via transmission line (wires) from the power plant to the consumer.
    - c. This is so because alternating current electrocity can be transformed --- the voltage can be increased or decreased by means of transformers.
    - d. Alternate in electricity means to change or reverse direction regularly and continually. (reverse the direction of the flow of electrons)
    - e. 60 Cycle Alternating Current: This is the standard alternating current in use today. IT MEANS that the electrons are changing their direction of flow 60 times every second. Actually, an incandescent bulb is flashing on and off 60 times each second, but the human eye cannot detect this rapid flashing --- it interprets it as a steady light.
    - f. Produced by means of induction:(I) induction in electricity means the process by which an electrical current is produced when a conductor is exposed to a magnetic force, OR the process by which a magnetic field is produced in or around an electrical conductor.
    - g. Generator of dynamo: A machine for changing mechanical energy into electrical energy by means of induction.
    - h. Turbine: A power wheel with many curved vanes and driven by a pressure of steam, water or air. Used to power generators and other mechanical devices.
2. Direct Current:
    - a. This type of electricity is used exclusively in motor vehicles, aircraft, diesel-electric locomotives, portable radios, etc. --- It is sometimes used in remote areas where electric power for a farm home, cabin, etc. is produced by means of wind or water driven generator.
    - b. It cannot be transformed readily, therefore it cannot be transmitted over a very long range. (distance)
    - c. Direct: in electricity means that the electrons flow in one direction only --- they do not change direction as in alternating current.
    - d. Produced by:
        - (1) Induction --- see "f" under alternating current.

        - (2) Chemical means: (a) dry cells and dry batteries
            (b) wet cells and storage storage batteries
            (c) solar cells and batteries.

ELECTRICITY

I. **OBJECTIVE**: To construct an electric panel which will show:

A. Overloaded circuit] and the hazards they present
B. Short circuit]
C. Safety devices
D. Parallel wiring of lights
E. Series wiring of lights
F. What a switch does to a circuit

II. **MATERIALS**:

A. Plywood or masonite, 1/4 inch thick, 18" X 24" --- 2 X 4 - 3 ft. long
B. Knife switch
C. 8 terminals
D. 6 feet number 12, white insulated copper wire
E. 6 feet number 12, black insulated copper wire
F. 2 feet nichrome wire
G. 8 porcelain receptacles
H. 4 alligator clips
I. One piece lumber; 3/4" thick X 3 1/2" X 30" long
J. 2 ampere fuses
K. 2 ampere circuit breaker
L. 6 - 100 watt bulbs

III. **PROCEDURE**:

A. Assemble panel as per illustration on next page
B. Perform various demonstrations as outlined in the following pages

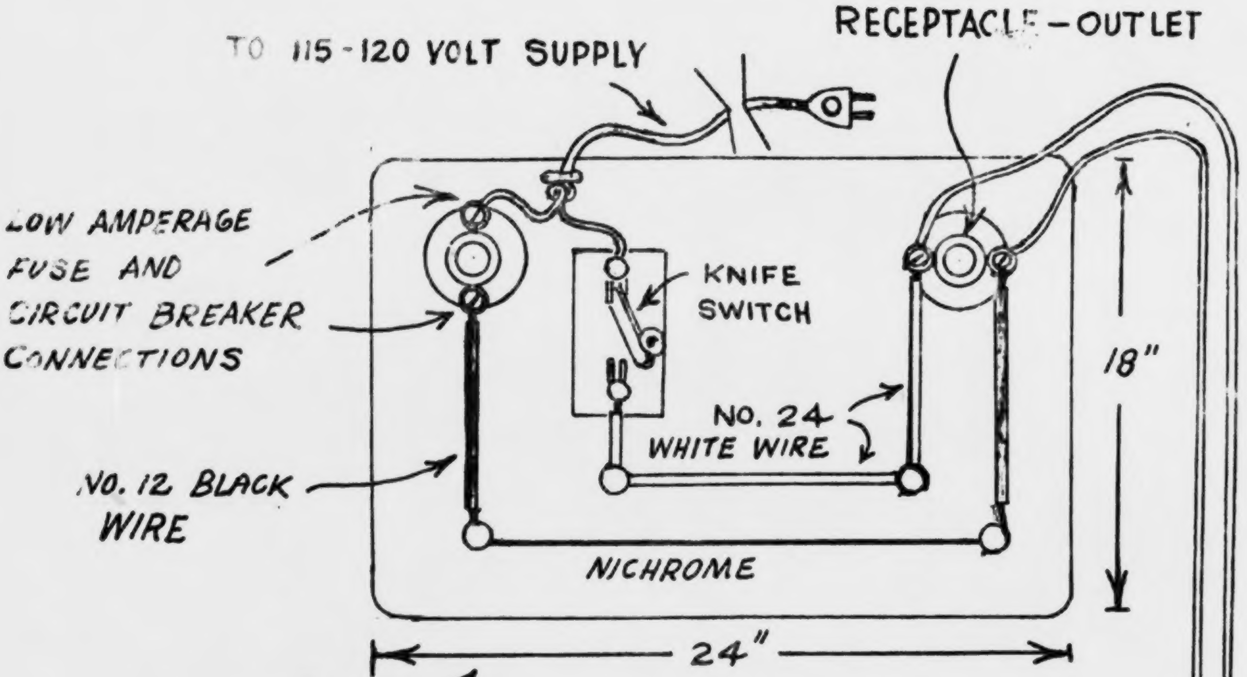

TO 115-120 VOLT SUPPLY
RECEPTACLE-OUTLET
LOW AMPERAGE FUSE AND CIRCUIT BREAKER CONNECTIONS
KNIFE SWITCH
18"
NO. 24 WHITE WIRE
NO. 12 BLACK WIRE
NICHROME
24"

FIGURE 1.

PARALLEL WIRING

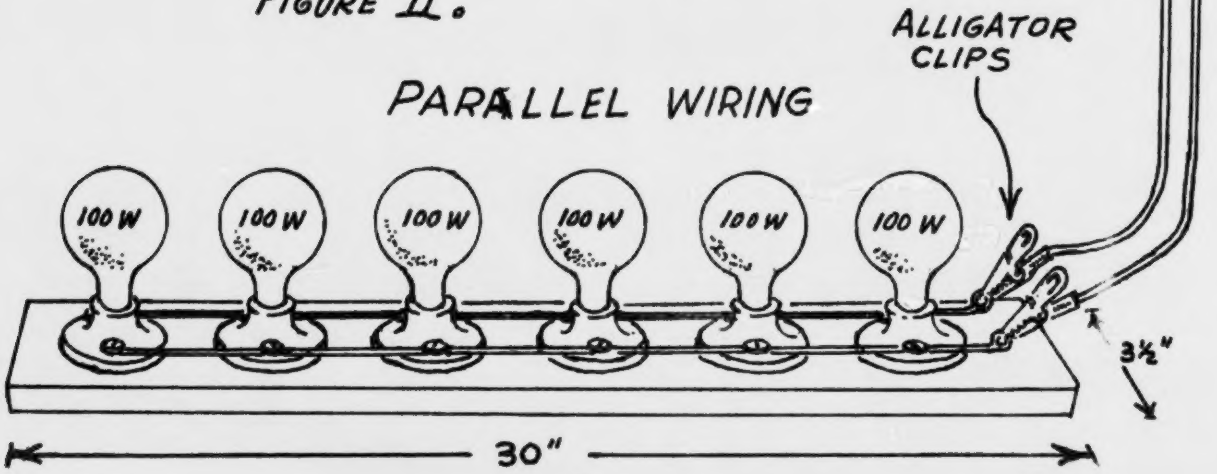

ALLIGATOR CLIPS
100 W
100 W
100 W
100 W
100 W
100 W
3½"
30"

FIGURE 2.

SERIES WIRING

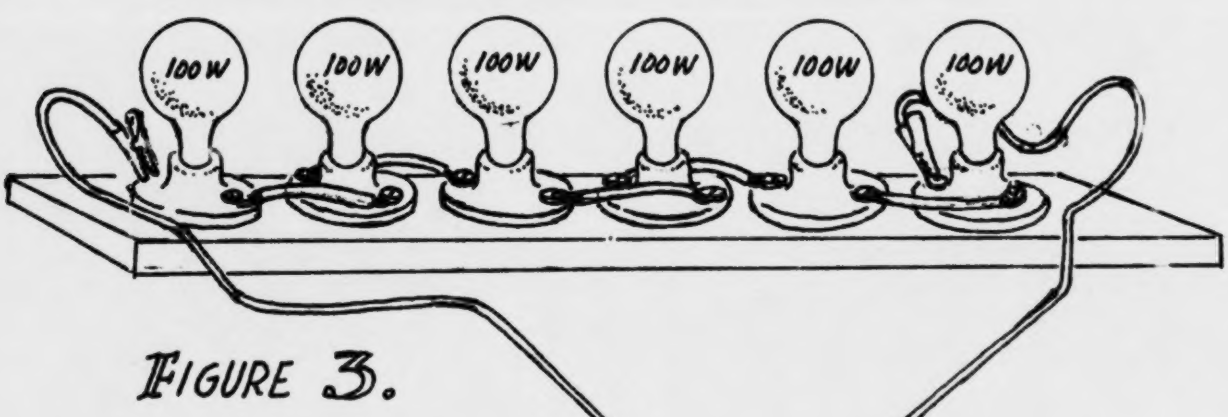

100 W
100W
100W
100W
100W
100W
TO 115-120 VOLT SUPPLY

FIGURE 3.

ELECTRICITY

I. OBJECTIVE: To show the main parts of an electric circuit

II. MATERIALS:

- A. Electrical panel board and equipment

III. PROCEDURE:

- A. Step by step, build the electric circuit as in Fig. 1
- B. Explain each part of the circuit as it is assembled
- C. When circuit is completed, close switch to see if current reaches light in upper right corner.
- D. Trace the path of the current
- E. DO NOT use the un-insulated nichrome wire on this demonstration
- F. Remove a black wire from any place in the circuit
- G. Remove a white wire from any place in the circuit

IV. OBSERVATIONS:

- A. All electrical circuits should contain:
  - (1) Safety device --- fuse or circuit breaker
  - (2) Switch --- for opening and closing the circuit conveniently
  - (3) Appliance --- any device that uses an electrical current
  - (4) 2 insulated copper wires of sufficient size, insulation on one is white and on the other is black

- B. When either a black or white wire is removed from the circuit, the flow of current stops

V. CONCLUSION:

- A. The fuse or circuit breaker is a safety device that protects the circuit in the event of a short circuit or an overload
- B. The switch is a device for conveniently opening and closing the circuit --- it might be compared with a drawbridge
- C. An electrical appliance is any device which uses electricity, such as a light bulb, radio, TV, heater, mixer, drill, etc.
- D. Two wires are essential for a complete circuit.

ELECTRICITY

I. **OBJECTIVE:** To demonstrate and explain parallel and series wiring of lights.

II. MATERIALS:

Electric panel board and equipment

III. PROCEDURE:

A. Set up panel as in Fig. 1, but using regular #12 wire instead of the thin nichrome wire. Use 15 amp or 25 amp fuse.
B. Attach light panel with extension and alligator clips, as in Fig. 2
C. Turn any of the six bulbs on or off. --- How does this affect the brilliance of the other bulbs? Try all sorts of arrangements.
D. Now attach light panel as in Fig. 3; NOTE WIRING ARRANGEMENT.
E. Have all bulbs turned on. Note the brilliance.
F. Remove any one bulb. What happens to the other bulbs?

IV. OBSERVATIONS:

A. In parallel wiring, all bulbs burn with equal brilliance
In parallel wiring, if one bulb is removed or burned out, the others continue to burn with the same brilliance. Our homes are wired in this manner.

B. In series wiring, if one bulb is removed or burned out, all bulbs go out.
In series wiring, the bulbs do not burn as brightly as in parallel wiring.
In series wiring, the filament of the bulb becomes part of the circuit. Some Christmas lights are wired in this manner.

V. CONCLUSION:

A. Parallel wiring is the more practical wiring for homes, schools, etc.

B. Series wiring is sometimes used in Christmas lights

ELECTRICITY

I. OBJECTIVE: To demonstrate and explain a short circuit.

II. MATERIALS:

Electric panel board and equipment

III. PROCEDURE:

A. Set up panel board as in Fig. 1 - use 25 amp fuse.
B. Place screw-type outlet in receptacle in upper-right corner.
C. Plug extension cord, with alligator clips on one end, in the outlet, being careful not to touch both ends at the same time.
D. Holding wires where insulated, cause alligator ends to contact one another by tapping together.
E. Observe thin wire and paper covering.
F. Repeat A through E, using a 2 ampere fuse, then a 2 amp circuit breaker.

IV. OBSERVATIONS:

A. There was a sparking when the bare alligator clips were touched.
B. The thin wire became overheated, causing the paper covering to catch fire.
C. The fuse did not blow. (25 amp fuse)
D. The 2 ampere fuse "blew" and the 2 ampere circuit breaker popped to the off position, thereby protecting the wires in the circuit. The thin wire did not get hot and the paper did not catch fire.

V. CONCLUSION:

A. If there is no safety device, or if the safety device is ineffective, (too large for the wire) a fire could result from a short circuit.
B. A fuse and a circuit breaker are safety devices. Do not tamper with them. Always be certain you are using the proper size.

VI. DISCUSSION:

Short circuit: The flow of electrons from their source and back to the source without going through an appliance.

It might well be called an "electron short cut." If the wires are not protected by the proper size fuse or circuit breaker, they will overheat and cause a fire.

ELECTRICITY

I. **OBJECTIVE**: To show an overload on a circuit and how a safety device protects the circuit.

II. **MATERIALS**:

Electric panel board and equipment

III. **PROCEDURE**:

A. Set up panel as in Fig. 1 and Fig. 2.
B. Place 2 ampere fuse in position.
C. Place folded paper over nichrome wire to simulate insulation.
D. One bulb at a time should be turned on with an interval of time lapsing before turning on the next bulb.
E. Observe paper covering thin wire.
F. Observe fuse.
G. NOTE: Explain that the thin wire is used so that a smaller overload can be created with less hazard to wiring on panel board and to the wiring in the building occupied.
H. Repeat A through F, this time using 2 ampere circuit breaker.
I. Repeat A through F, this time using a 25 amp fuse or circuit breaker.

IV. **OBSERVATIONS**:

A. The 2 ampere fuse "blew" shortly after the third bulb was turned on.
B. The thin wire or paper covering was not affected.
C. The circuit breaker "popped" to the off position shortly after the third bulb was turned on.
D. Again, neither the thin wire or the folded paper were affected.
E. The 25 ampere fuse did not "blow" --- allowing the thin wire to get very hot causing the folded paper to catch fire.

V. **CONCLUSION**:

A. The safety device, fuse, or circuit breaker, must be of the proper size in order to protect the circuit from an overload.
B. A fuse or circuit breaker that is too large for the size wire in the circuit is a hazard, rather than a safety device.
C. A fuse does not "blow", - it melts, thus causing an incomplete circuit.
D. A circuit breaker has a bi-metal strip which bends as it heats, thereby breaking contact before the wire gets too hot.

E. Practically all wires in our homes are in the walls, ceilings, and floors, thus if a fire should start as it did when the fuse was too large for the circuit, it may smolder undetected for hours and then burst into flames during the night while we are sleeping.

F. NEVER place a penny behind a blown fuse.
NEVER place to large a fuse or circuit breaker in a circuit.

VI. DISCUSSION:

Overload: forcing more electrons through a conductor than the conductor is capable of carrying safely. This causes the conductor (wire) to become overheated.

ELECTRICITY

I. **OBJECTIVE:** To explain how to cut away dry cell batteries and how these cut-a-way batteries can be utilized in the classroom.

II. **MATERIALS:**

- A. Various sizes and types of dry cell batteries
- B. Can opener---various types
- C. Screw drivers --- various sizes
- D. Pliers
- E. Sharp knife
- F. Rubber bands

III. **PROCEDURE:**

A. In all metal case lantern-type battery, use wheel cutter type of can opener to remove top, just as if a can were being opened. After you have cut completely arounds the top, pry gently and lift the lid, being careful not to break any of the connecting wires.

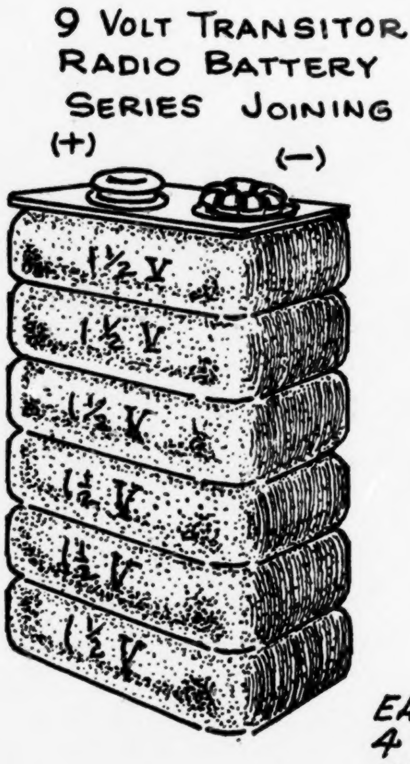
B. If battery is a metal case type with a cardboard or composition top and bottom, use a thin screwdriver to pry open the metal case at the seam. Gently spread and remove metal jacket and, using pliers, pinch folded edge of case together so that it will not present a hazardous sharp edge. The cardboard top, bottom or both can now be removed or folded back. Likewise, the paper inner liner can be folded back to expose the cells.

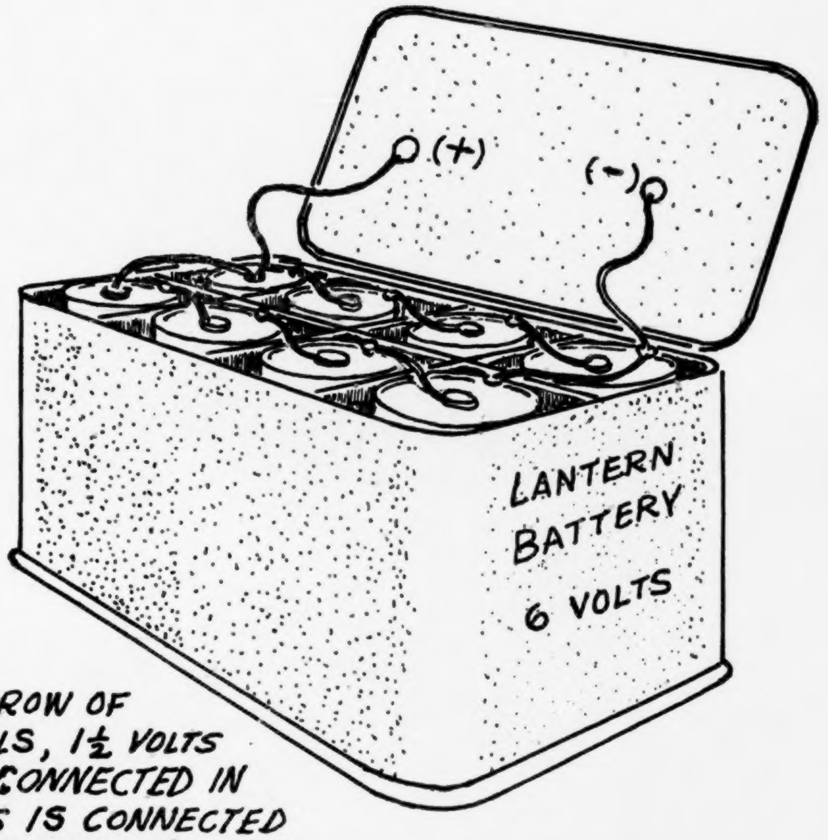
C. For the popular 9 volt transistor battery, follow instructions in "B"

D. If the battery jacket is paper or cardboard completely, a sharp knife is all that is necessary to open it completely. Simply cut along three edges so that the battery can be opened like a door to expose the cells.

E. Use rubber bands to hold batteries and cases together.

ELECTRICITY


9 Volt Transitor
Radio Battery
Series Joining
(+)
(−)
1½ V
1½ V
1½ V
1½ V
1½ V
1½ V


(+)
(−)
LANTERN
BATTERY
6 VOLTS

EACH ROW OF 4 CELLS, 1½ VOLTS EACH, CONNECTED IN SERIES IS CONNECTED TO THE OTHER ROW IN PARALLEL .... SERIES TO YIELD 6 VOLTS AND PARALLEL TO INCREASE THE CURRENT...

IV. OBSERVATIONS:

A. Each dry cell produces 1 1/2 volts of electricity, therefore a 6 volt battery would be expected to contain four cells, --- a 9 volt battery 6 cells, --- a 45 volt battery would contain 30 cells, etc., all of which would be joined in series. HOWEVER, some batteries contain twice the number of cells you might expect. Each pair of cells is joined in parallel to form a battery, then each of these 1 1/2 volt batteries are joined in series to form a battery of higher voltage.

V. CONCLUSION:

A. These cut-a-way batteries can be used in the classroom from year to year.
B. Students are a good source of worn out batteries to be cut away.

ELECTRICITY

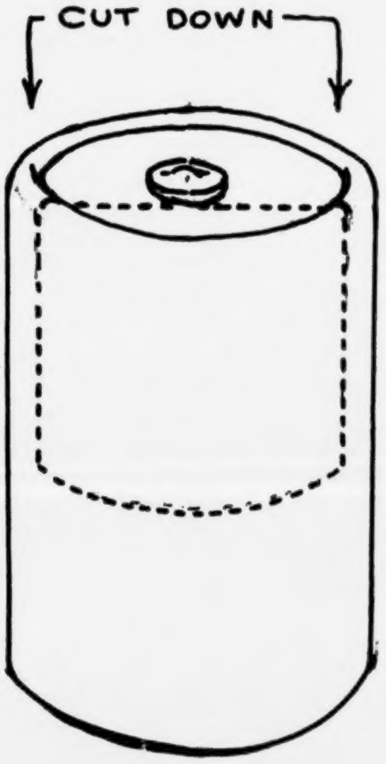
I. OBJECTIVE: To explain how to cut away the various sizes of dry cells.

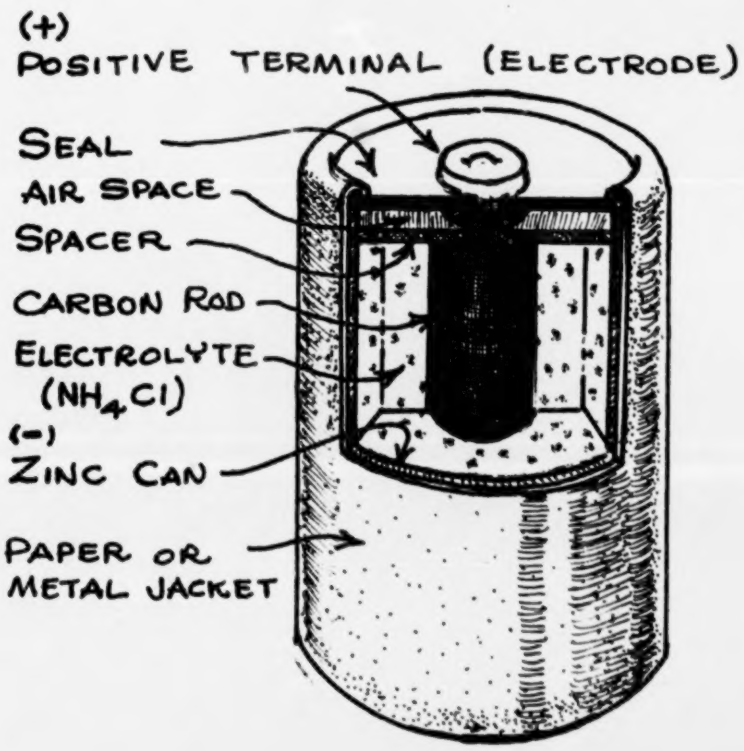
II. MATERIALS:

A. Various sizes of dry cells to be cut away
B. Hack saw
C. Patience

III. PROCEDURE:

A. Fasten selected dry cell securely in a vice or clamp, or have another person hold securely.
B. Cut from top downward, slightly off center, as indicated by dotted line.
C. Cut inward from the side until meeting other cut, then remove loose section.
D. Peel back a portion of the paper or metal jacket so that zinc can is exposed.




(+)
POSITIVE TERMINAL (ELECTRODE)
SEAL
AIR SPACE
SPACER
CARBON ROD
ELECTROLYTE
(NH_4Cl)
(-)
ZINC CAN
PAPER OR
METAL JACKET

ELECTRICITY

IV. OBSERVATIONS:

A. Cell cuts quite easily with a good hack saw.

B. Cutting away the above part exposes the internal parts of a dry cell.

C. All dry cells, regardless of physical size, are constructed the same.

D. The black substance (electrolyte) is messy.

V. CONCLUSION:

A. These cut-a-way cells can be utilized in the teaching of electricity and how it is produced by chemical action.

B. The size of a dry cell determines how long an electric current can be produced, not the voltage produced.

C. Each dry cell, regardless of its physical size, produces 1 1/2 volts.

D. If you can get your husband or wife, or anyone else to cut away the cell, you will save yourself a real mess. Lots of luck!

ELECTRICITY

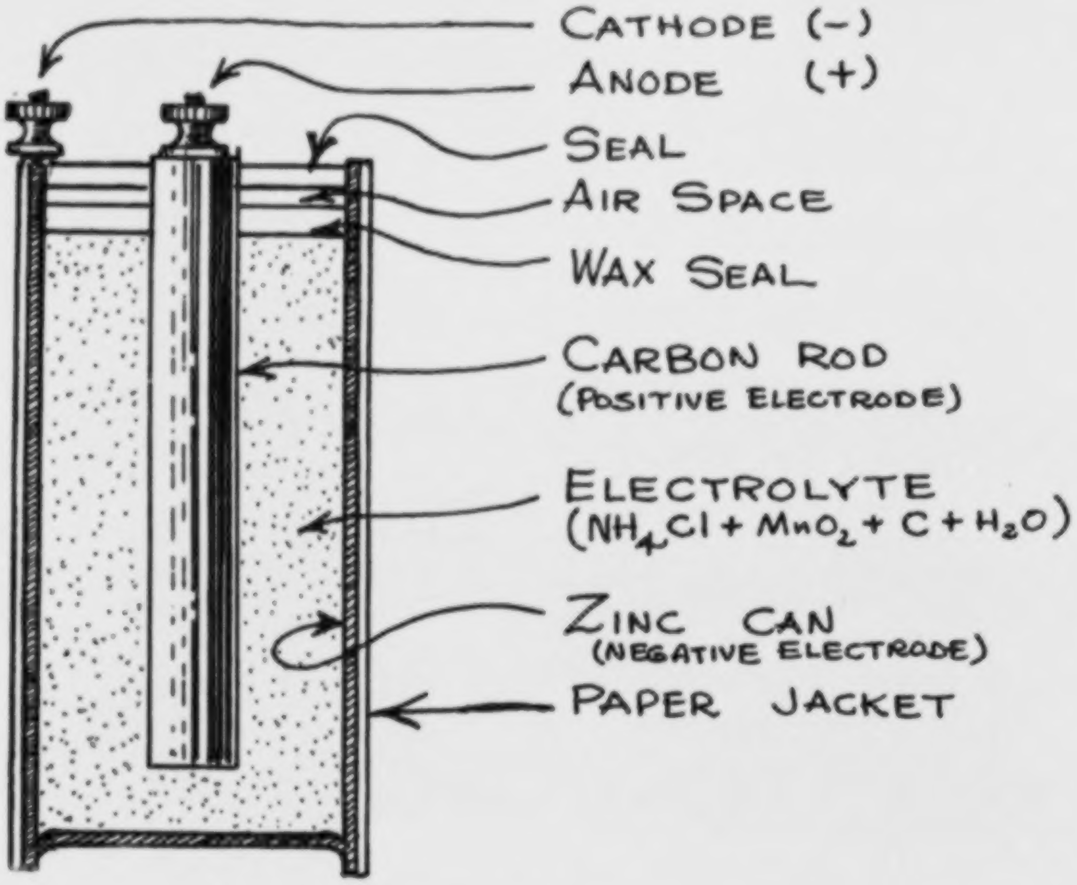
I. OBJECTIVE: To explain the operation of a dry cell and show the various parts.

II. MATERIAL:

A. Various sizes and types of cut-a-way dry cells.
B. Various sizes and types of working dry cells.

III. PROCEDURE:

A. Display the various cut-a-way cells
B. Point out the various parts as in illustration below
C. Check voltage on the various sized cells. Record this reading


CATHODE (–)
ANODE (+)
SEAL
AIR SPACE
WAX SEAL
CARBON ROD
(POSITIVE ELECTRODE)
ELECTROLYTE
$(NH_4Cl + MnO_2 + C + H_2O)$
ZINC CAN
(NEGATIVE ELECTRODE)
PAPER JACKET

IV. OBSERVATIONS:

A. All dry cells displayed are constructed in the same manner
B. The electrolyte consists of a moist paste
C. Each cell, regardless of size, produces 1-1/2 volts when new

V. CONCLUSION:

A. A flashlight "battery is actually a cell.
B. The size of a cell determines its hours of use, not voltage.
C. A dry cell is actually not dry, the electrolyte is a moist paste.
D. A dry cell produces electricity by chemical means.
E. The current flows from the cathode (–) to the anode(+)

ELECTRICITY

I. OBJECTIVE: To show how to cut away a 6 or 12 volt storage battery

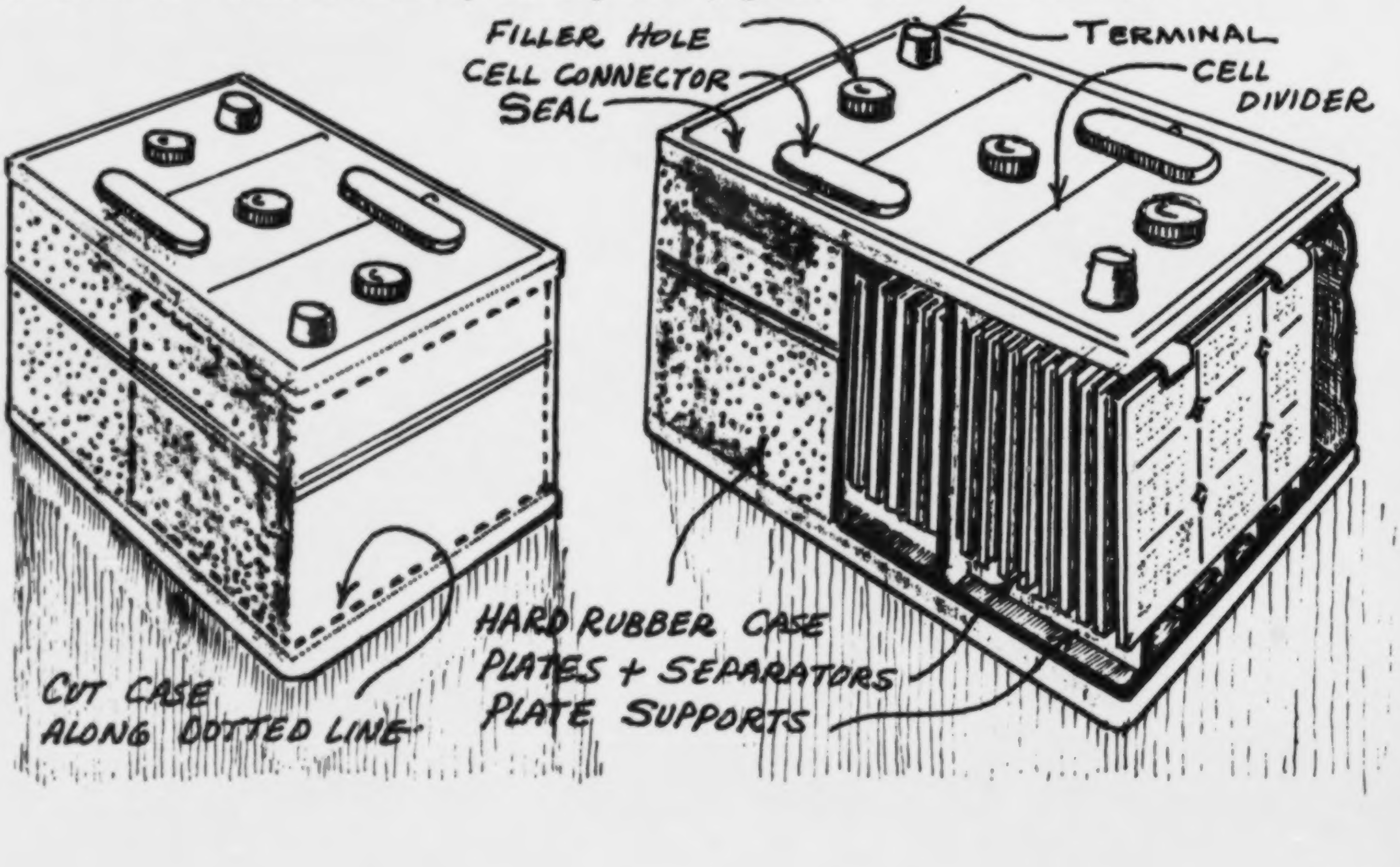
II. MATERIALS:

A. 6 or 12 volt battery to be cut away
B. Hack saw
C. Cold chisel
D. Screw driver
E. Hammer

III. PROCEDURE:

A. Wear old clothes
B. IMPORTANT: thoroughly flush all cells several times with a supply of running water to remove all traces of sulfuric acid (H_2SO_4)

C. Cut along dotted line with hack saw and chisel, whichever works best. This must be done carefully so as not to damage plates or crack the entire case,
D. After you are certain that you have cut through the hard rubber case where indicated by the dotted line, remove this portion by prying carefully with chisel and screw driver
E. Once this section has been removed, again thoroughly flush all cells several times with running water
F. Clean the entire battery of any acid, grease or oil residues.


FILLER HOLE
CELL CONNECTOR
SEAL
TERMINAL
CELL DIVIDER
CUT CASE ALONG DOTTED LINE
HARD RUBBER CASE
PLATES + SEPARATORS
PLATE SUPPORTS

IV. OBSERVATIONS:

A. This is really a mess. By all means, try to get your wife, husband or a friend to do this for you.

B. Cutting away the above part exposes the internal parts of one of the cells.

C. Wet cells are constructed by the same --- the material in the plates and the number of plates per cell, however, may vary.

V. CONCLUSION:

A. A storage battery does not store electricity, --- it stores the chemicals and other substances necessary to produce electricity by chemical action.

B. This cut-a-way battery can be utilized to help explain the production of electricity by chemical means.

C. Direct current (D.C.) electricity is produced by chemical means.

D. A battery is two or more cells joined together.

E. A wet cell produces 2.2 volts when fully charged.

ELECTRICITY

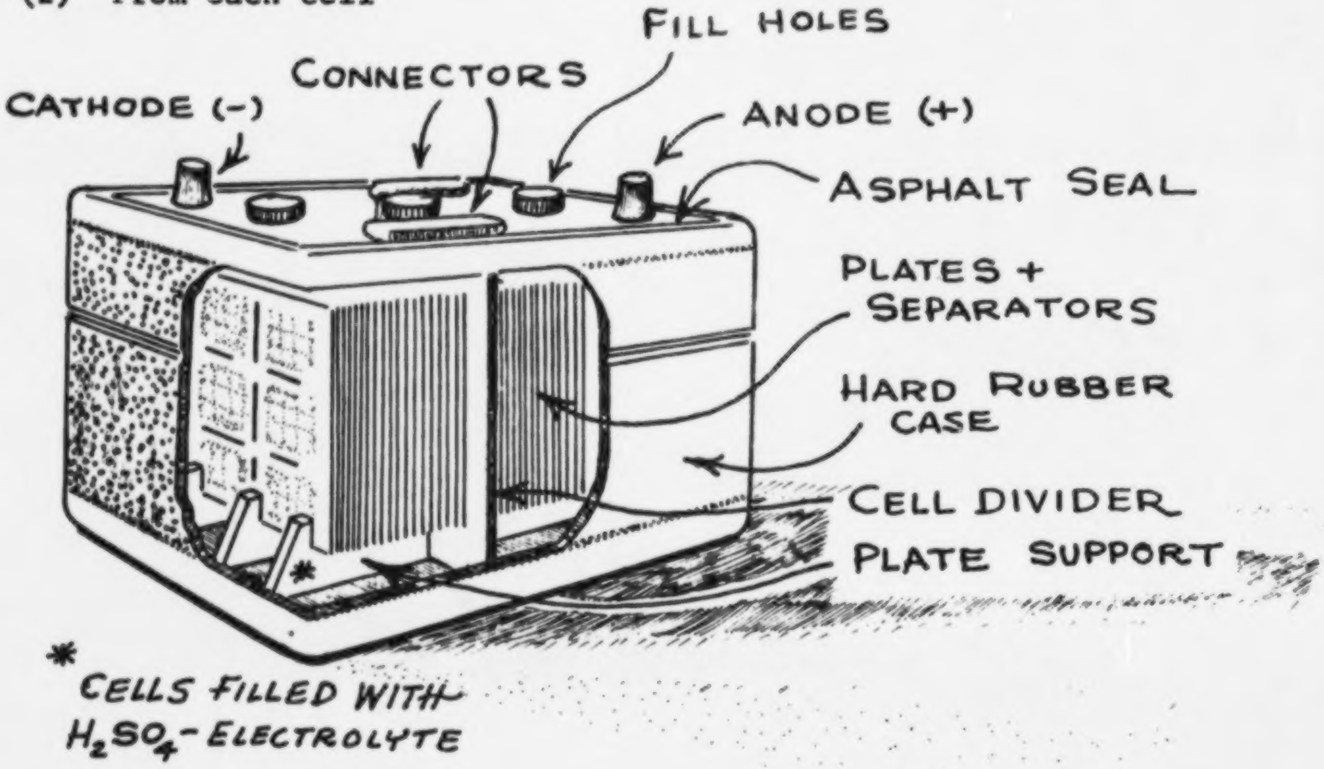
I. **OBJECTIVE:** To explain the operation of a storage battery (wet battery) and show the various parts:

II. **MATERIALS:**

- A. Cut-a-way storage battery, 6 or 12 volts
- B. Working storage battery, 6 or 12 volts
- C. Voltmeter

III. **PROCEDURE:**

- A. Display cut-a-way battery
- B. Point out various parts and explain
- C. Check voltage from working battery
  - (1) Total voltage
  - (2) From each cell


FILL HOLES
CONNECTORS
CATHODE (-)
ANODE (+)
ASPHALT SEAL
PLATES + SEPARATORS
HARD RUBBER CASE
CELL DIVIDER
PLATE SUPPORT
*
* CELLS FILLED WITH H_2SO_4 - ELECTROLYTE

IV. **OBSERVATIONS:**

A. Voltage from each cell was 2 volts
B. Total voltage --- 3 cells = 6 volts
6 cells = 12 volts

V. **CONCLUSION:**

- A. A battery is two or more cells joined together.
- B. A wet cell produces about 2.2 volts when fully charged.
- C. A wet battery can be charged.
- D. A storage battery does not store electricity, it stores the chemicals necessary to produce an electric current.
- E. Wet and dry cells and batteries produce D.C. (direct current)

ELECTRICITY

I. OBJECTIVE:

A. To show the difference between a cell and a battery
B. To show series joining of cells
C. To show parallel joining of cells

II. MATERIALS:

A. Voltmeter
B. Connecting wires
C. 4 flashlight cells
D. Aluminum foil
E. Cut-a-way batteries, (dry) series and parallel joined

III. PROCEDURE:

A. Connect the four cells in parallel as in Fig. 1 below
B. Connect the four cells in series as in Fig. 2 below
C. Observe the various joinings of the cells in the cut-a-way batteries

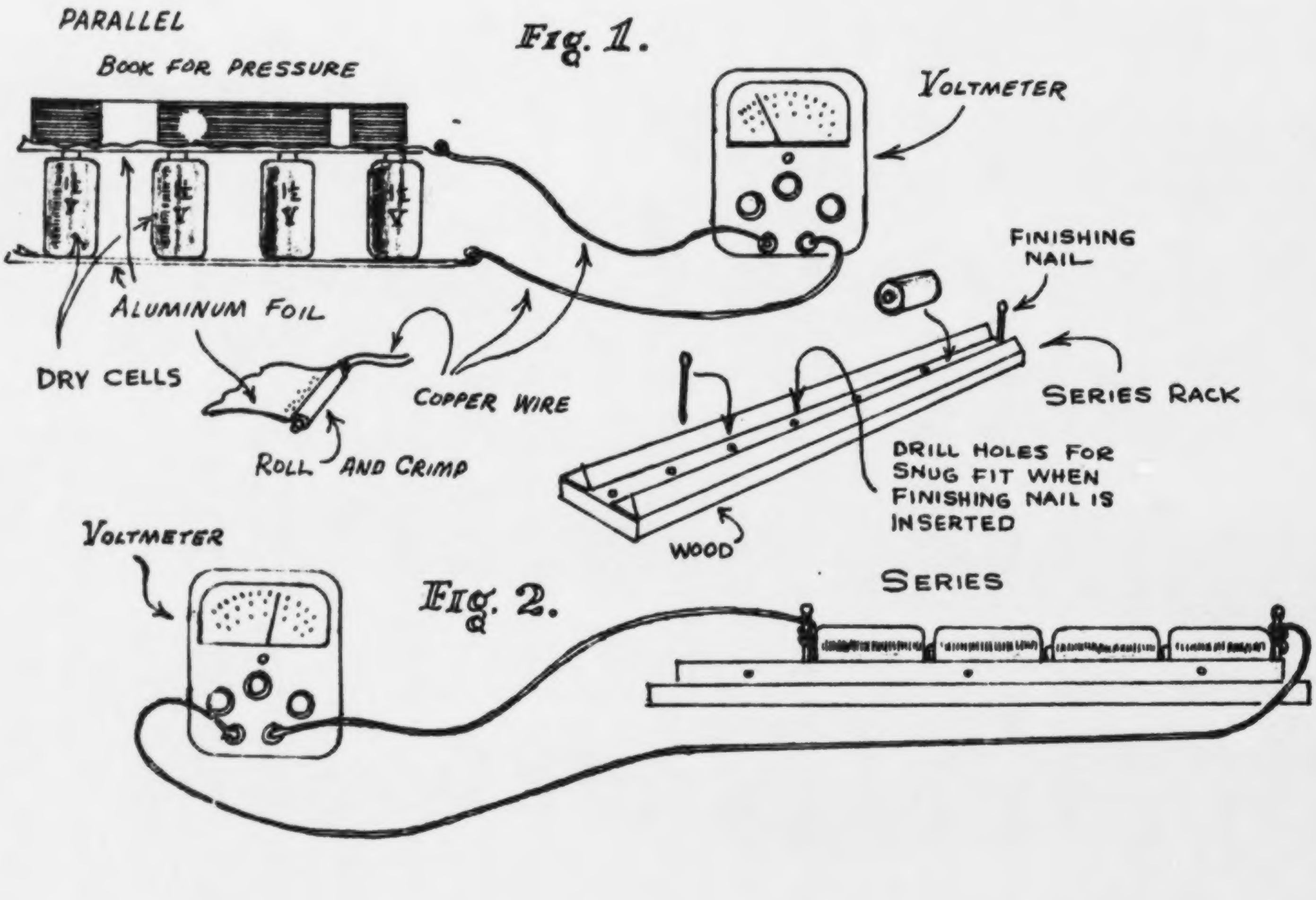

PARALLEL
BOOK FOR PRESSURE
VOLTMETER
ALUMINUM FOIL
DRY CELLS
COPPER WIRE
ROLL AND CRIMP
FINISHING NAIL
SERIES RACK
DRILL HOLES FOR SNUG FIT WHEN FINISHING NAIL IS INSERTED
WOOD
VOLTMETER
SERIES

Fig. 1.

Fig. 2.

ELECTRICITY

IV. OBSERVATIONS:

A. Voltmeter reading when cells connected in parallel ________________.

B. Voltmeter reading when cells connected in series __________________.

V. CONCLUSION:

A. Parallel joining of cells does not increase the voltage, it increases the length of time the voltage could be used.

B. Series joining of cells increases the voltage by the number of cells joined in this manner.

C. A battery is two or more cells joined together.

ELECTRICITY

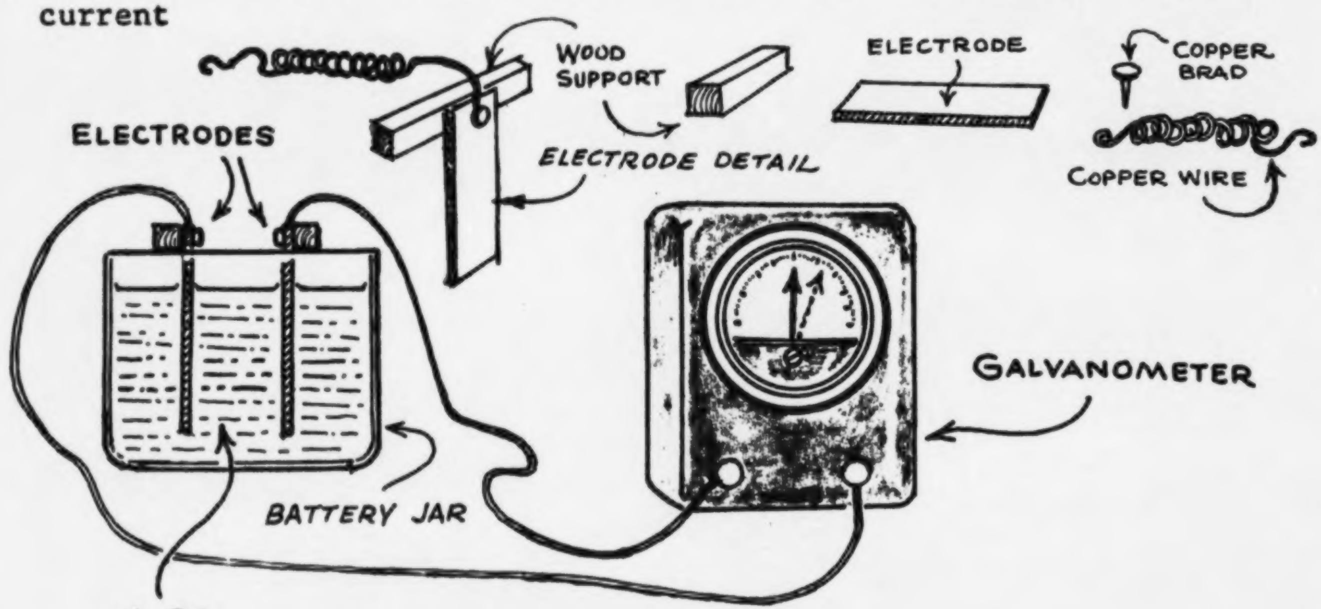
I. OBJECTIVE: To construct and study the characteristics of a simple wet cell (voltaic cell).

II. MATERIALS:

- A. Large beaker or small battery jar
- B. Zinc metal ---- round and flat pieces
- C. Carbon, round and flat
- D. Brass, lead, aluminum, tin, nickel, copper
- E. Milliammeter
- F. Galvanometer
- G. Connecting wires
- H. Sulfuric acid, concentrated
- I. Holder for metal strips

III. PROCEDURE:

- A. Set up equipment as illustrated below
- B. Sulfuric acid should have a specific gravity of 1.3
- C. Check current produced with various metals as electrodes
- D. Vary the size of the electrodes and check current produced
- E. Vary the distance of the electrodes are from one another -- check current


WOOD SUPPORT
ELECTRODE
COPPER BRAD
ELECTRODES
ELECTRODE DETAIL
COPPER WIRE
GALVANOMETER
BATTERY JAR

H_2SO_4 DILUTED FROM A SPECIFIC GRAVITY OF 1.98 TO 1.30.
CAUTION: ADD ACID TO WATER FOR INITIAL DILUTION. TEST WITH HYDROMETER ~

ELECTRICITY

IV. OBSERVATIONS:

A. Readings with various metals for electrodes

(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
(10)

B. How did the size of the electrodes affect current produced?

C. How did the distance the electrodes were from one another affect the current produced?

V. CONCLUSION:

A. Type metal or metals best for electrodes?
B. Size of electrodes best for producing current?
C. Best spacing of electrodes?

ELECTRICITY

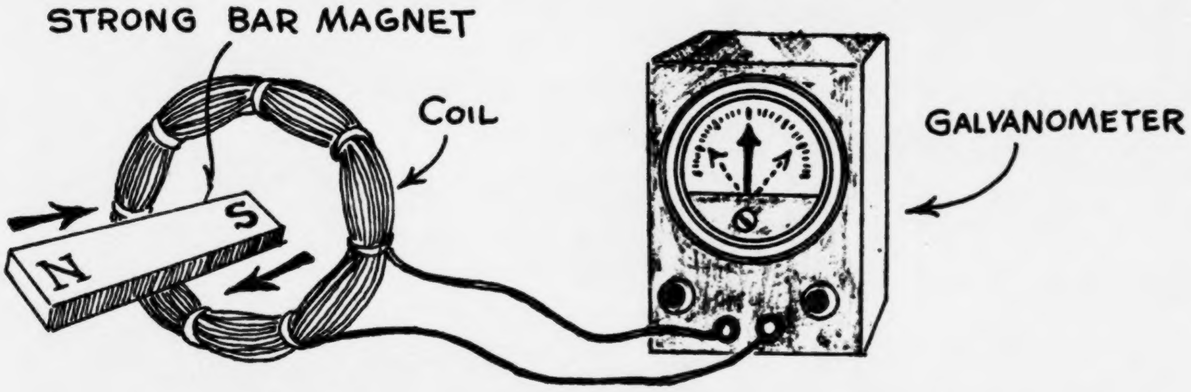
I. OBJECTIVE: To show how current electricity is produced by induction.

II. MATERIALS:

- A. Demonstration galvanometer
- B. Strong bar magnets
- C. Coil of fine, insulated copper wire

III. PROCEDURE:

A. Set up apparatus as shown below. Record all observations.



B. Move magnet back and forth through the coil and observe needle on galvanometer.

C. Keeping N and S poles together, add another magnet and repeat "B".

D. Add more turns to the coil of wire and repeat "B".

E. Repeat "B" but move magnet more rapidly.

IV: OBSERVATIONS:

A. (1) In what direction did the needle on the galvanometer move? (In "B")
   (2) What was the reading in "B"?
   (3) Was alternating or direct current electricity produced?

B. What was the reading in "C"?
Compare this reading with "B"

C. What was the reading in "D"? Compare with "B"

D. What is the reading in "E" ? Compare with "B".

E. Are there any other observations?

V. **CONCLUSION:**

A. When the lines of magnetic force are broken by a conductor, the electrons in the conductor are caused to flow due to induction.

B. As one pole of the magnet passed through the coil of wire, the needle moved in one direction, --- then it moved in the other direction as the opposite pole passed through the coil. Alternating current electricity was produced.

C. The stronger the magnetic field, the greater the current produced.

D. The greater the number of turns on the coil of wire, the greater the current produced.

E. As the speed with which the lines of magnetic force are broken is increased, so is the current increased.

VI. **DISCUSSION:**

Galvanometer: An instrument for determining the intensity and direction of an electrical current.

ELECTRICITY

I. OBJECTIVE:

A. To show the main parts of a generator
B. To show the difference between an A.C. and D.C. generator

II. MATERIALS:

A. Demonstration galvanometer
B. St. Louis Motor - generator
C. Lead wires

III. PROCEDURE:

A. Connect galvanometer to generator with the solid ring commutator in place.

B. Spin the armature and observe galvanometer. Record results.

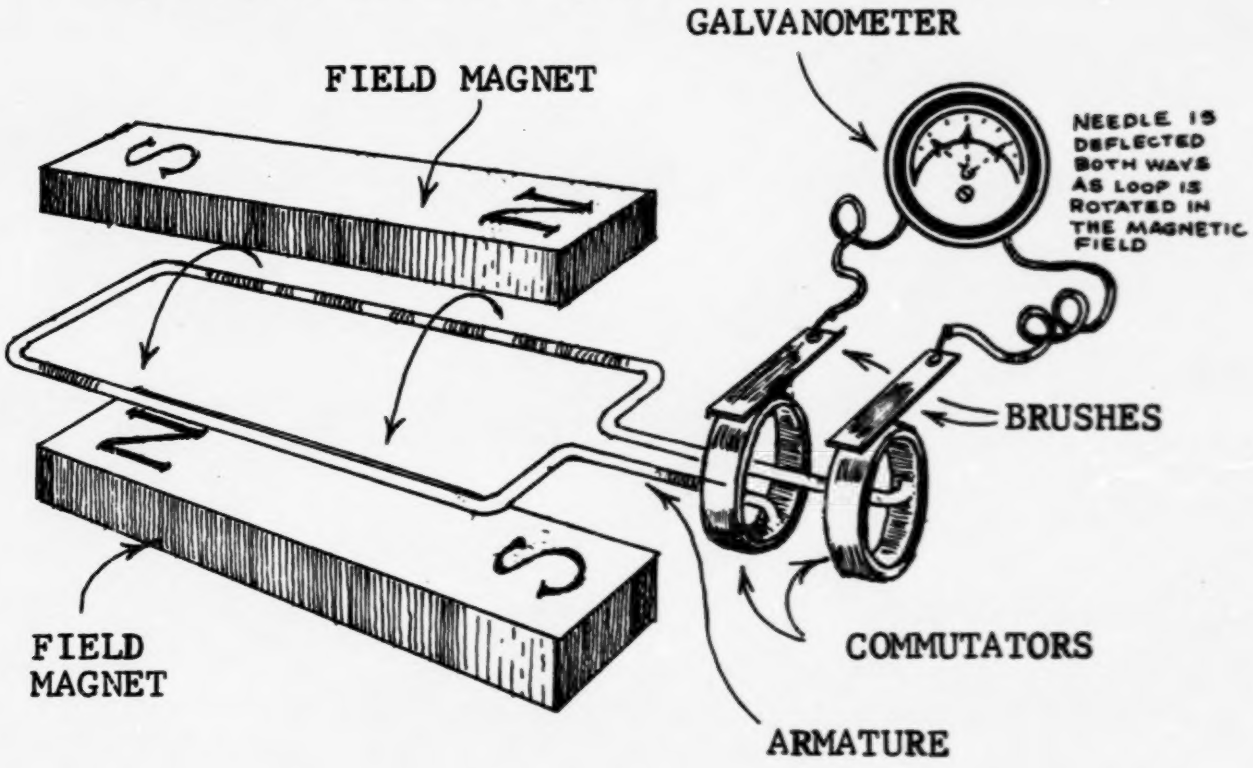
C. Repeat A & B using split ring commutator. Record results.

D. Locate the following parts on the generator; explain their function:

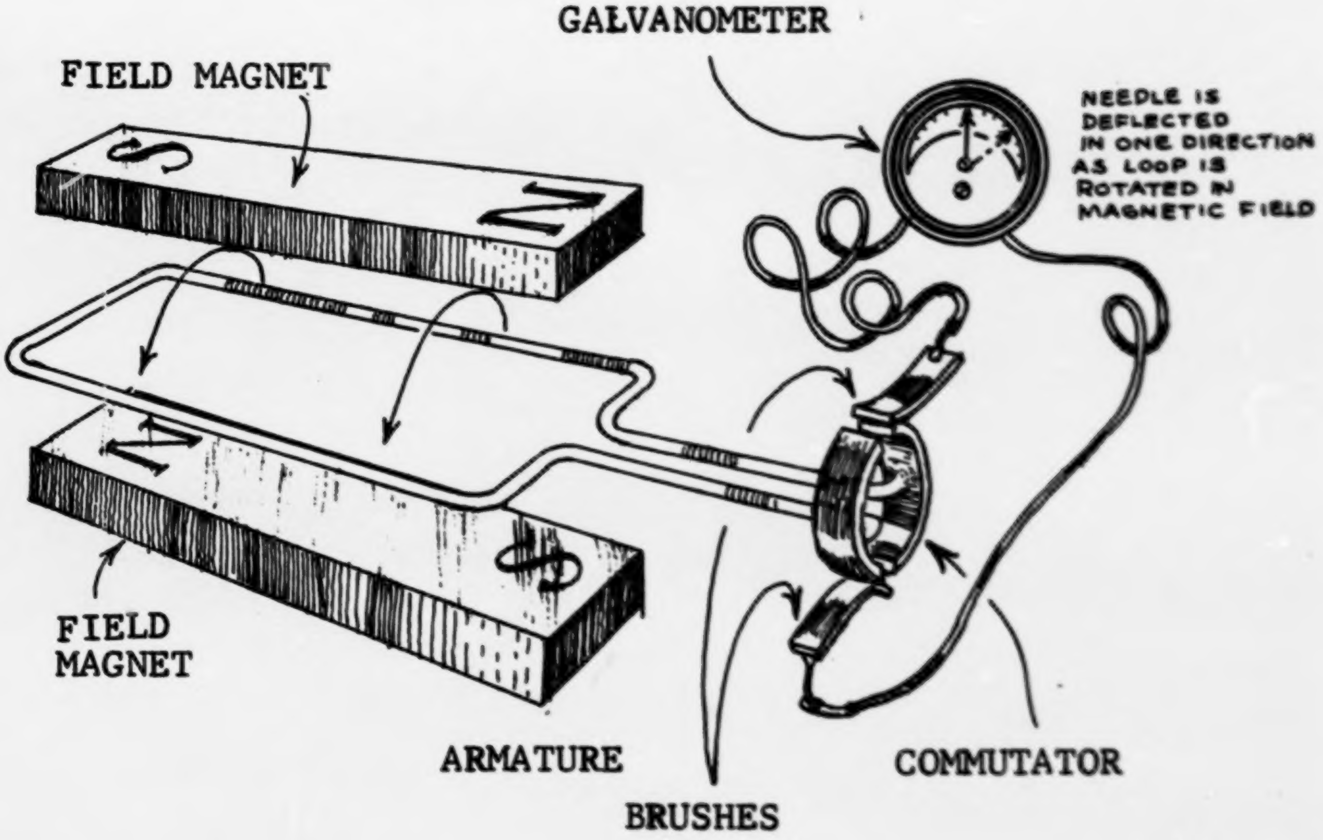
(1) Armature
(2) Field magnets
(3) Commutator
(4) Brushes

(See illustrations on the following page)

ALTERNATING CURRENT GENERATOR


GALVANOMETER
FIELD MAGNET
S
N
NEEDLE IS DEFLECTED BOTH WAYS AS LOOP IS ROTATED IN THE MAGNETIC FIELD
N
BRUSHES
S
FIELD MAGNET
COMMUTATORS
ARMATURE

DIRECT CURRENT GENERATOR


GALVANOMETER
FIELD MAGNET
NEEDLE IS DEFLECTED IN ONE DIRECTION AS LOOP IS ROTATED IN MAGNETIC FIELD
S
N
N
S
FIELD MAGNET
ARMATURE
COMMUTATOR
BRUSHES

IV. OBSERVATIONS:

A. Solid ring commutator causes A.C. electricity to be produced
B. Split ring commutator causes D.C. electricity to be produced

V. CONCLUSION:

A. The only difference between an A.C. generator and a D.C. generator is the commutator.

(1) A solid ring commutator produces A.C. current
(2) A split ring commutator produces D.C. current

VI. DISCUSSION:

A. Armature: a coil of wire around a soft iron core that revolves in a magnetic field of an electric motor or generator.

B. Fields: consists of magnets, either permanent or electro, of a motor or generator.

C. Commutator: the revolving ring that collects the current from the armature.

D. Brushes: the carbon or other material used to collect and conduct the current from the commutator to an outside source.

ELECTRICITY

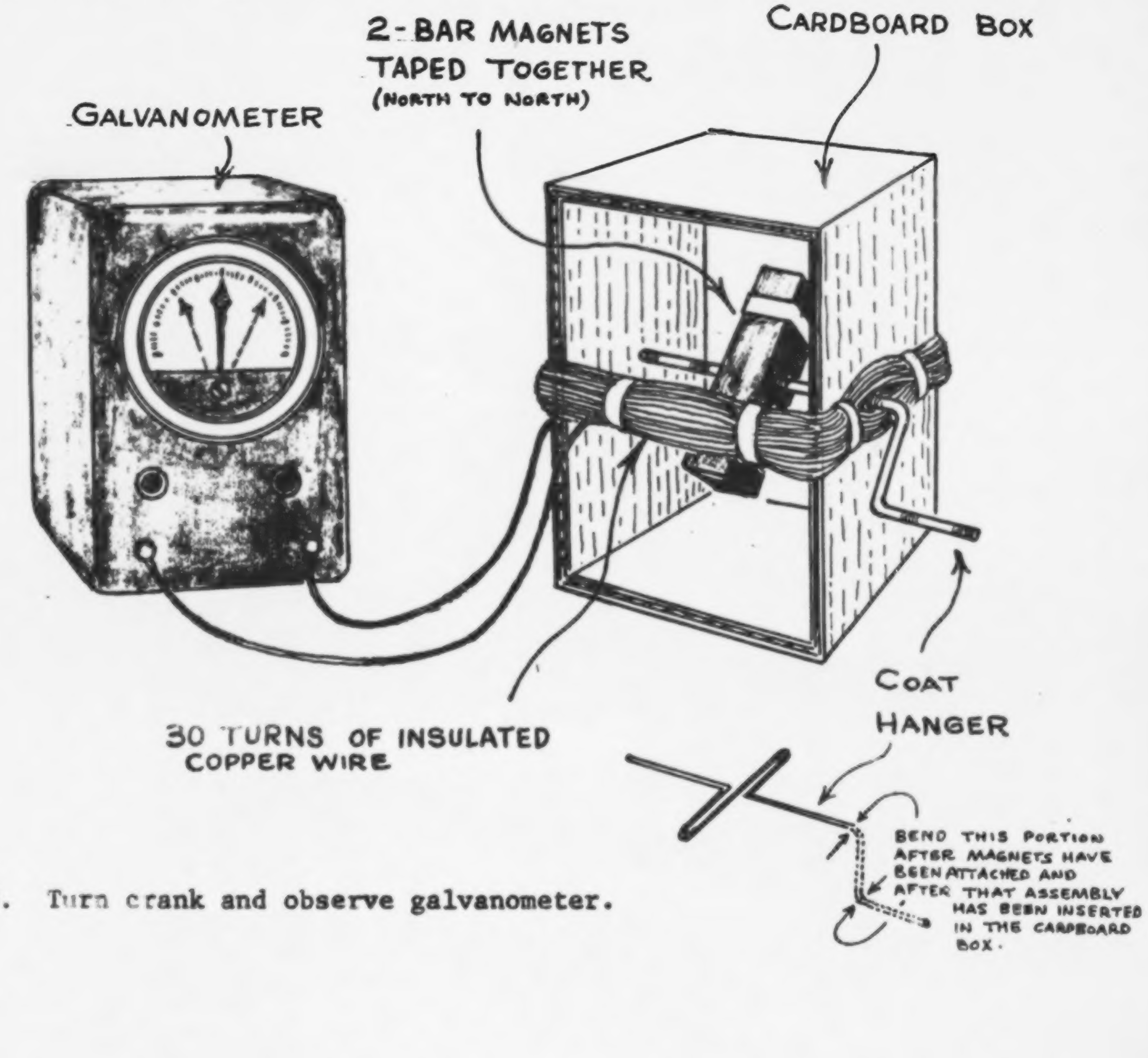
I. OBJECTIVE: To construct a simple A. C. generator.

II. MATERIALS:

- A. Two bar magnets
- B. Demonstration galvanometer
- C. Coil of fine insulated wire
- D. Cardboard or wooden box
- E. Masking tape or rubber bands
- F. Wire coat hanger

III. PROCEDURE:

A. Construct apparatus as shown below.


2-BAR MAGNETS
TAPED TOGETHER
(NORTH TO NORTH)
CARDBOARD BOX
GALVANOMETER
30 TURNS OF INSULATED COPPER WIRE
COAT HANGER
BEND THIS PORTION AFTER MAGNETS HAVE BEEN ATTACHED AND AFTER THAT ASSEMBLY HAS BEEN INSERTED IN THE CARDBOARD BOX.

B. Turn crank and observe galvanometer.

IV. OBSERVATIONS:

As the crank of the generator is turned, the needle of the galvanometer swings first to the right, then to the left.

V. CONCLUSION:

A. As the poles of the magnet move to the opposite side, the needle of the galvanometer swings in the opposite direction.

B. Since the current is changing direction, this is A. C. or alternating current.

C. In most generators, the magnetic field remains stationary while the coil of wire (armature) revolves within this field.

D. A direct current (D. C.) generator works in the same manner. The only difference is that the commutator is of the split ring type.

ELECTRICITY

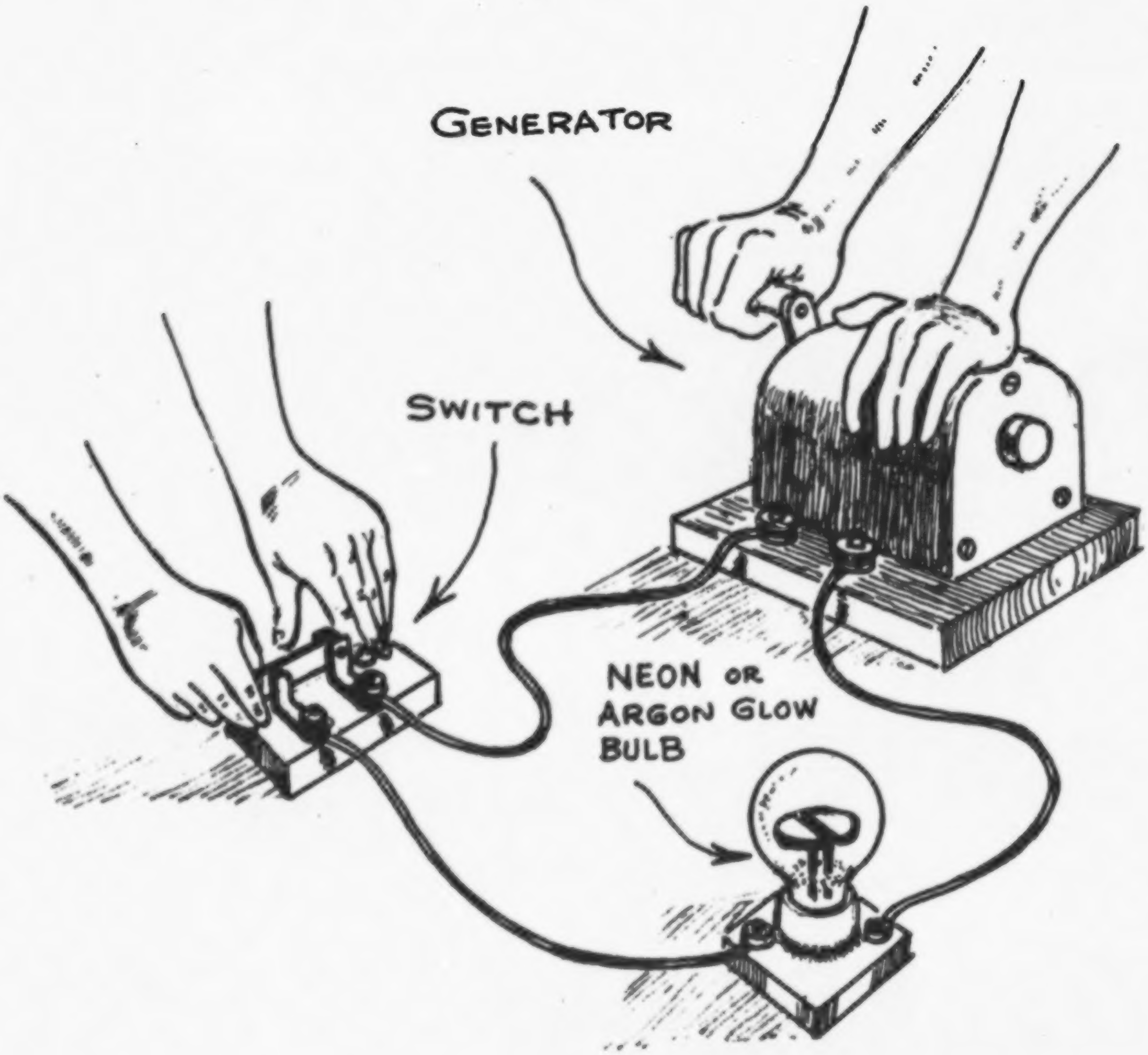
I. **OBJECTIVE:** To explain and show effects of A.C. electricity.

II. **MATERIALS:**

A. Hand operated generator ---- 90 to 100 volt capacity
B. Neon or argon glow bulb ---- 2 watt

III. **PROCEDURE:**

A. Place neon bulb in the socket, close switch, turn generator slowly and observe the bulb.
B. Now turn crank faster and observe the bulb.
C. Turn as fast as possible and observe the bulb.
D. Continue cranking and have someone open the switch


GENERATOR
SWITCH
NEON OR ARGON GLOW BULB

IV. OBSERVATIONS:

A. Bulb flashed on and off as generator was turned slowly
B. Bulb flashed on and off more rapidly as crank was turned faster
C. Flashing of the light bulb could not be detected when crank was turned rapidly
D. When switch was open, less effort was required to turn the crank

V. CONCLUSION:

A. Cycles per second are determined by the speed of rotation of the armature of a generator. The standard is 60 cycle alternating current.
B. This means that the current (electrons) are changing their direction 60 times every second.
C. The human eye cannot detect a cycling (flashing) of more than 60 times per second. This is why an incandescent bulb appears to glow steadily. Actually it is flashing on and off 60 times per second.
D. As the speed of rotation is increased, the lines of magnetic force are broken more rapidly resulting in a more rapid flashing of the bulb.

GEOLOGY

CONTENT:

INTRODUCTION

VOCABULARY

CONCEPT

To explain specific gravity and to demonstrate how it can be determined.

To show how the approximate hardness of a mineral can be determined by use of common items.

To explain what a mineral streak is and to show it can be determined.

To show how to construct paper models of the six common mineral crystal forms.

To show how wind affects sand: How sand dunes are formed.

To show how wind causes waves.

To show how density or turbidity currents are formed.

To show how lime is formed from limestone.

To demonstrate and explain permeability.

To show the simple acid test for limestone and dolomite.

To show how caves and sinkholes are formed in limestone layers.

To demonstrate how rock formations are warped without breaking.

To construct a model seismograph.

GEOLOGY

Introduction

A. Geology, in a large part, is devoted to a study of the lithosphere, its rocks, history, modifications, movements, structures, and wealth of resources. Atmosphere and water, acting upon the earth's crust, have played a ceaseless role in its several transformations, and these factors should be considered while studying the branch of science known as geology.

B. Fields of Geology
Several geology-related fields of endeavor provide opportunities for those seeking professions which are oriented toward science. The following list of geologists, with descriptions of their work, is an example:

1. Petroleum geologist: seek deposits of petroleum and natural gas, which are our principal mineral fuels and our most valuable mineral product.
2. Mining geologist: search for deposits of minerals and rocks which are of economic value to man.
3. Ground-water geologist: help in locating supplies of underground water for domestic and industrial uses.
4. Mineralogist: identify minerals and study their physical and chemical properties.
5. Petrologist: specialize in the study of the composition and origin of rocks.
6. Paleontologist: work with fossils, the remains or traces of past life naturally preserved in rocks.
7. Stratigraphers: study the order in which the rocks were formed, so as to guide the search for such materials as petroleum and uranium.
8. Structural geologist: study the architecture, or arrangement, of the rocks of the earth's crust, important in oil fields and mining districts.
9. Engineering geologist: study the application of geology to engineering projects such as tunnels, dam sites, water reservoirs, highways and railroad construction, foundations and construction materials.
10. Geomorphologist: study the nature and origin of landscapes.

GEOLOGY

I. OBJECTIVE: To explain specific gravity and to demonstrate how it can be determined.

II. MATERIALS:

- A. Spring scale
- B. Beaker
- C. Water -- Distilled water is preferable
- D. Thread
- E. Various specimens of the same mineral and rock
    1. Pure quartz (If available)
    2. Pure calcite (If available)
    3. Limestone
    4. Sandstone
    5. Quartzite

III. PROCEDURE:

- A. Set up apparatus as illustrated in Fig. A.
- B. Weigh each of the specimens and record.
- C. Now weigh and record the weight of each specimen as it is suspended in water as in Fig. B.
- D. Determine the specific gravity of each specimen by using the following formula:

$$\text{SPECIFIC GRAVITY} = \frac{\text{WEIGHT OF SPECIMEN IN AIR}}{\text{WEIGHT IN AIR MINUS THE WEIGHT IN WATER}}$$

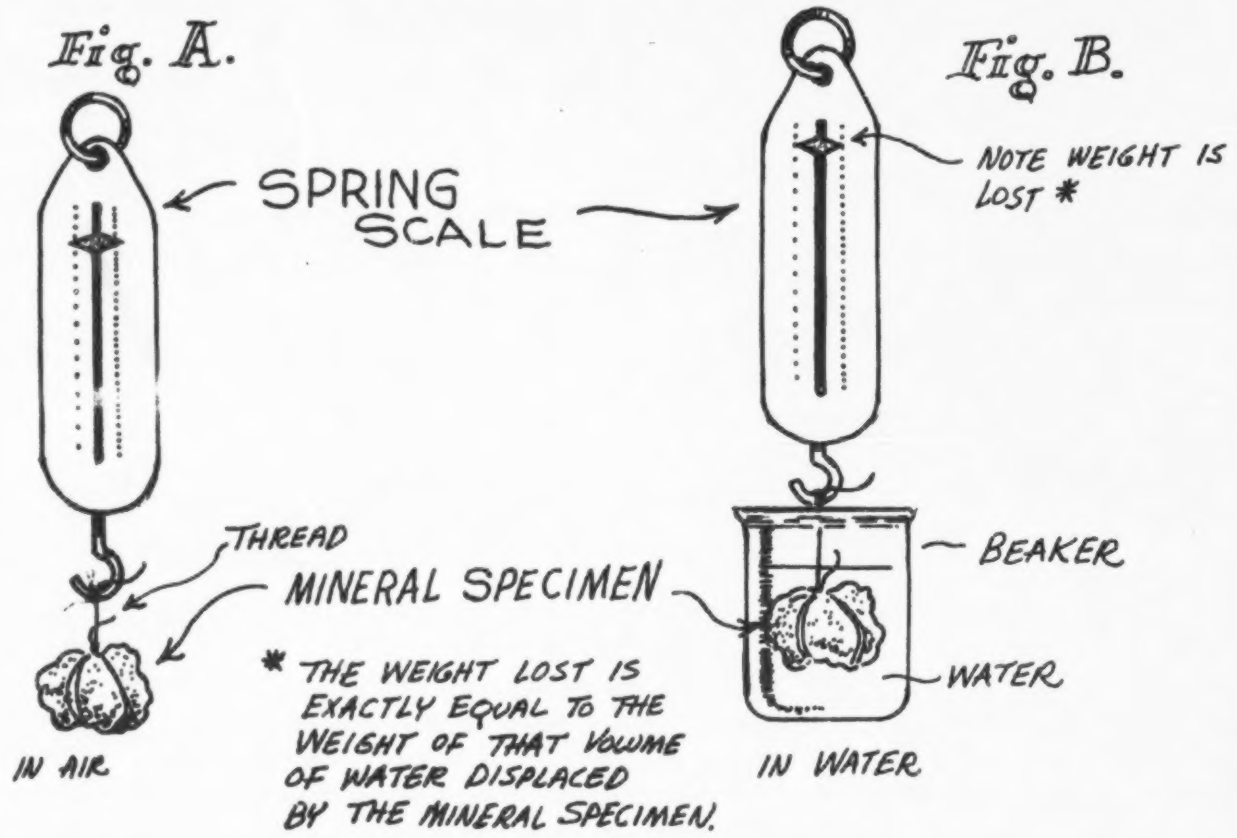


Fig. A.
Fig. B.
SPRING SCALE
NOTE WEIGHT IS LOST *
THREAD
MINERAL SPECIMEN
BEAKER
WATER
IN AIR
IN WATER

* THE WEIGHT LOST IS EXACTLY EQUAL TO THE WEIGHT OF THAT VOLUME OF WATER DISPLACED BY THE MINERAL SPECIMEN.

GEOLOGY

IV. OBSERVATIONS:

A.	Pure Quartz					
B.	Pure Calcite					
C.	Limestone					
D.	Sandstone					
E.	Quartzite					

V. CONCLUSION:

A. If pure specimens, the following specific gravities should prevail:

1. Pure Quartz -----------2.6
2. Pure Calcite ---------2.7
3. Limestone ----------varies
4. Sandstone ----------varies
5. Quartzite ---------varies

B. Only if a specimen is known to be pure will its specific gravity aid in identification.

GEOLOGY

I. OBJECTIVE: To show how the approximate hardness of a mineral can be determined by use of common items.

II. MATERIALS:

A. Fingernail ---------------2.5
B. Copper penny -------------3.0
C. Window glass -------------5.5
D. Knife blade --------------5.5
E. Steel file ---------------6.5
F. Magnifying glass
G. Several samples of different rocks and minerals
H. Hammer
I. Mohs Scale of Hardness ------ Set of specimens

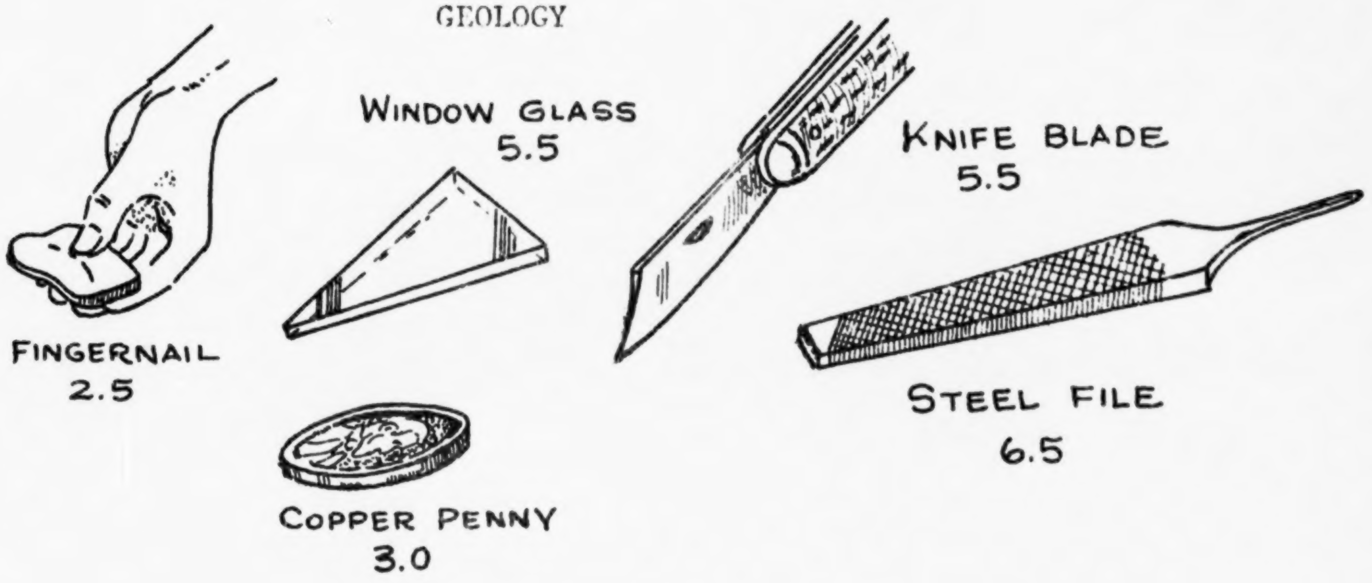
1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase (Feldspar)
7. Quartz
8. Topaz
9. Carborundum
10. Diamond

III. PROCEDURE:

A. Using the hammer, make certain that you have a fresh break in each of the specimens to be tested
B. Place all of the specimens that can be scratched with the fingernail in one pile ---- these specimens are not as hard as 2.5.
C. Those that can be scratched with a penny are not as hard as 3.0 and should be placed in another pile.
D. The same is true with a knife blade and steel file --- place specimens that can be scratched in their respective piles.
E. Any specimens that cannot be scratched with the steel file is between 6.5 and 10 in hardness.
F. If you have a set of specimens representing Mohs Scale of Hardness you can determine the hardness of the above minerals very closely by following the above procedures.

NOTE:

Be certain that the specimen has actually been scratched and not just marked by the other specimen or object. Check this closely by using a good magnifying glass. Have an old piece of window glass handy-- DO NOT try this on windows at school or at home.


FINGERNAIL
2.5
WINDOW GLASS
5.5
KNIFE BLADE
5.5
STEEL FILE
6.5
COPPER PENNY
3.0

IV. OBSERVATIONS:

A. Results will vary depending upon the type of specimens utilized.

V. CONCLUSION:

A. This is a rough means in determining the hardness, but serves as a practical method in determining the identity of unknown specimens.

NOTE: DO NOT attempt to test the hardness of a valuable crystal, specimen from a collection or a gem-stone.

B. There are more precise ways of measuring hardness in the industrial laboratory.

C. Hardness is the resistance to being scratched.

D. A handbook on rocks and minerals is invaluable in identifying minerals.

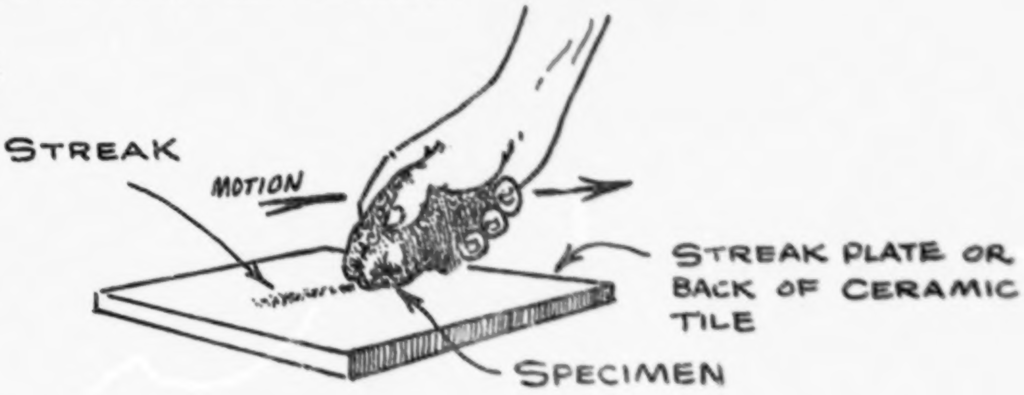
GEOLOGY

I. OBJECTIVE: To explain what a mineral streak is and to show how it can be determined.

II. MATERIALS:

A. Streak plate (The back of a ceramic tile is excellent.) Any unglazed porcelaine makes a good streak plate.
B. Various specimens of metallic and non-metallic minerals
C. Handbook on rocks and minerals.

III. PROCEDURE:


STREAK
MOTION
STREAK PLATE OR BACK OF CERAMIC TILE
SPECIMEN

A. Check the color of the streak (powdered mineral) of the various specimens and record.
B. If the identity of the specimen is unknown, a hardness check and reference to the rocks and mineral handbook will be of help.
C. Using the eraser of a pencil, make certain the streak plate is clean when you are finished.

IV. OBSERVATIONS:

A. The streak of a mineral is not always the same color as its solid form.

V. CONCLUSION:
A. As a general rule, the streak of a metallic mineral is black or darker than its lump form.
EXAMPLE:
  1. Iron pyrite crystals are brass-yellow -- their streak greenish-yellow
  2. Hematite is red or black -- its streak always reddish-brown
B. The streak of non-metallic minerals is usually colorless to white, or lighter in color than the lump specimen
C. Streak alone is not sufficient in identigying a mineral, but when used in conjunction with hardness, crystal form, color, luster, etc. it can be quite useful.

GEOLOGY

I. OBJECTIVE: To show how to construct paper models of the six common mineral crystal forms.

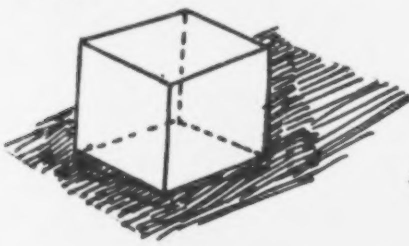
II. MATERIALS:

A. Six sheets of construction or manilla paper, 8" X 10"
B. Six cut-out stencils of the basic crystal forms.
C. Glue or paste
D. Scissors or razor blade

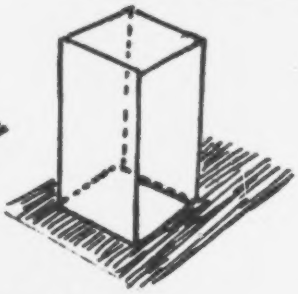
III. PROCEDURE:

A. Trace and cut out each of the crystal forms. (If razor blade is used, use a cardboard or soft wood backing so that table or desk will not be marred.)
B. Fold on the solid lines.
C. Place a small amount of glue or paste on tabs and fasten together in proper order. Do the sides first, then each end.

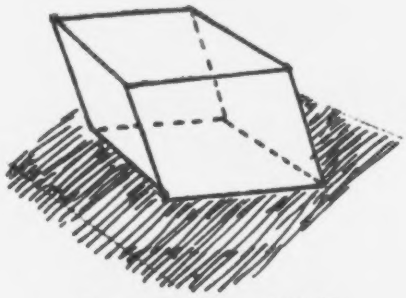
ISOMETRIC OR CUBIC



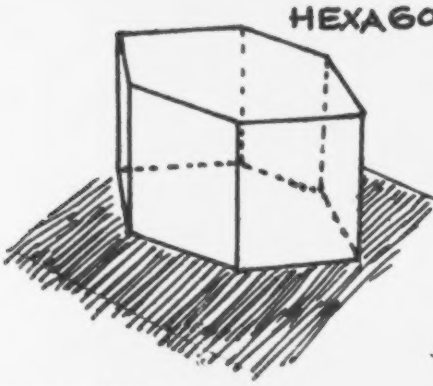
TETRAGONAL



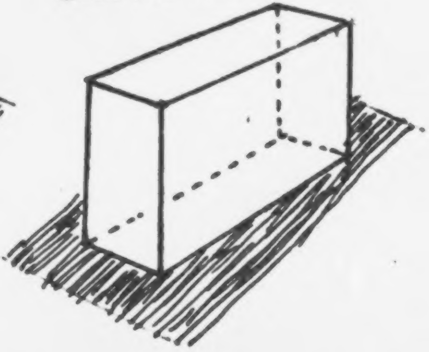
TRICLINIC



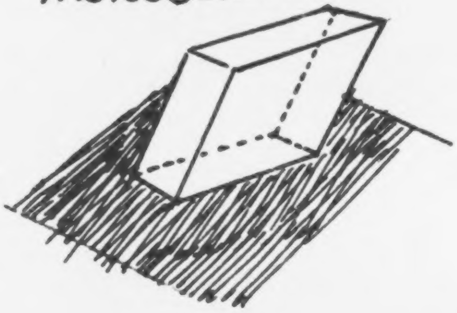
HEXAGONAL



ORTHORHOMBIC



MONOCLINIC



IV. OBSERVATION:

A. In one class period these six basic crystal-form models can be constructed
B. Various colors for the different forms would help the students to associate the different forms with the different colors.

V. CONCLUSION:

A. These models should aid the student in understanding the basic crystal form
B. Crystal form is very important in mineral identification.

1. Isometric or cubic, in which the three axes are at right angles as in a cube, and of equal length.

2. Tetragonal, in which the three axes are at right angles to each other, but only the two lateral axes are equal.

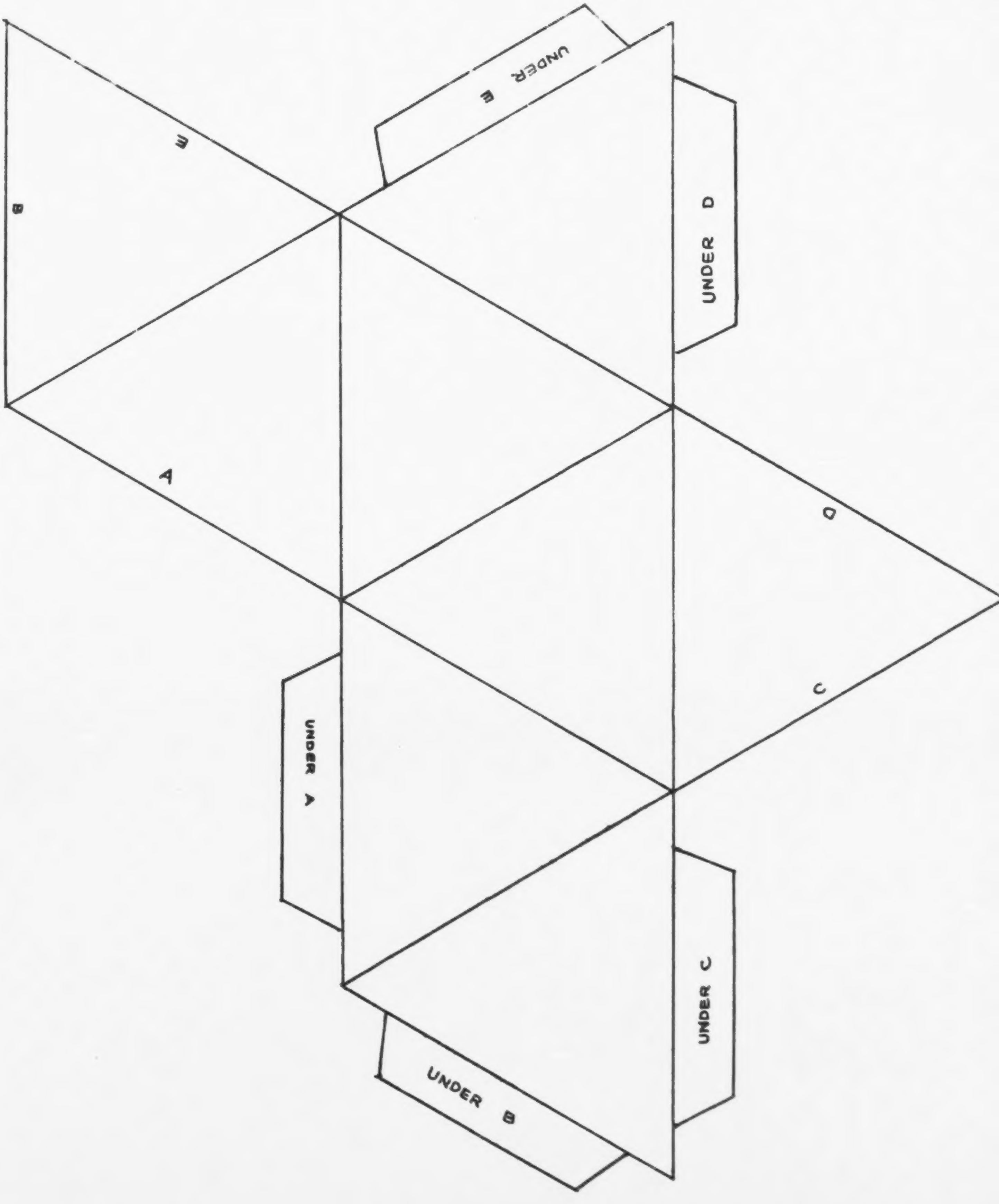
3. Triclinic, in which there are three unequal axes and oblique intersections.

4. Hexagonal, in which the equilateral axes intersect at angles of 60° and with a vertical axis of variable length at right angles to the equilateral axes.

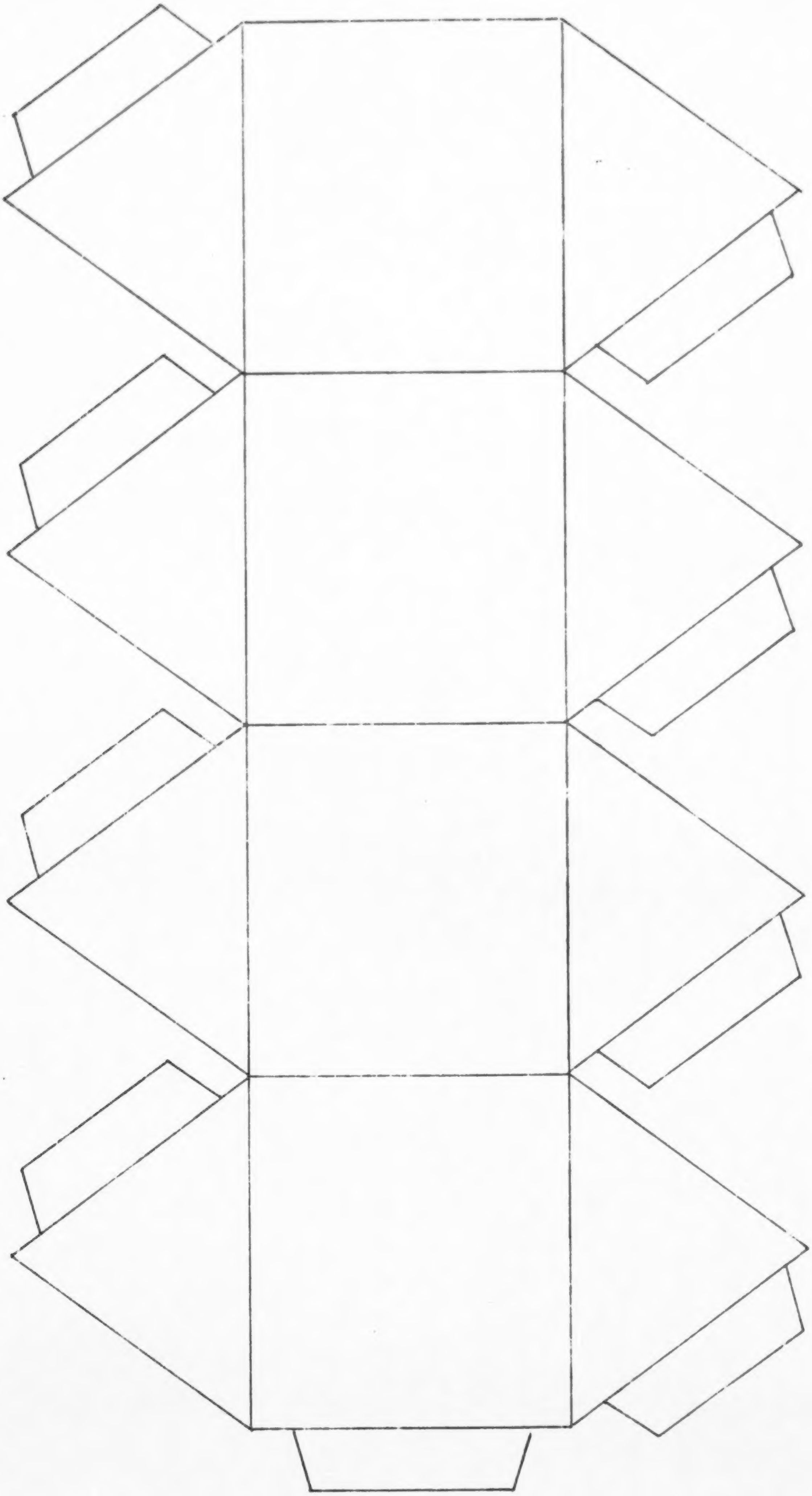
5. Orthorombic, in which there are three unequal axes at right angles to each other.

6. Monoclinic, in which there are three unequal axes, with one oblique intersection.

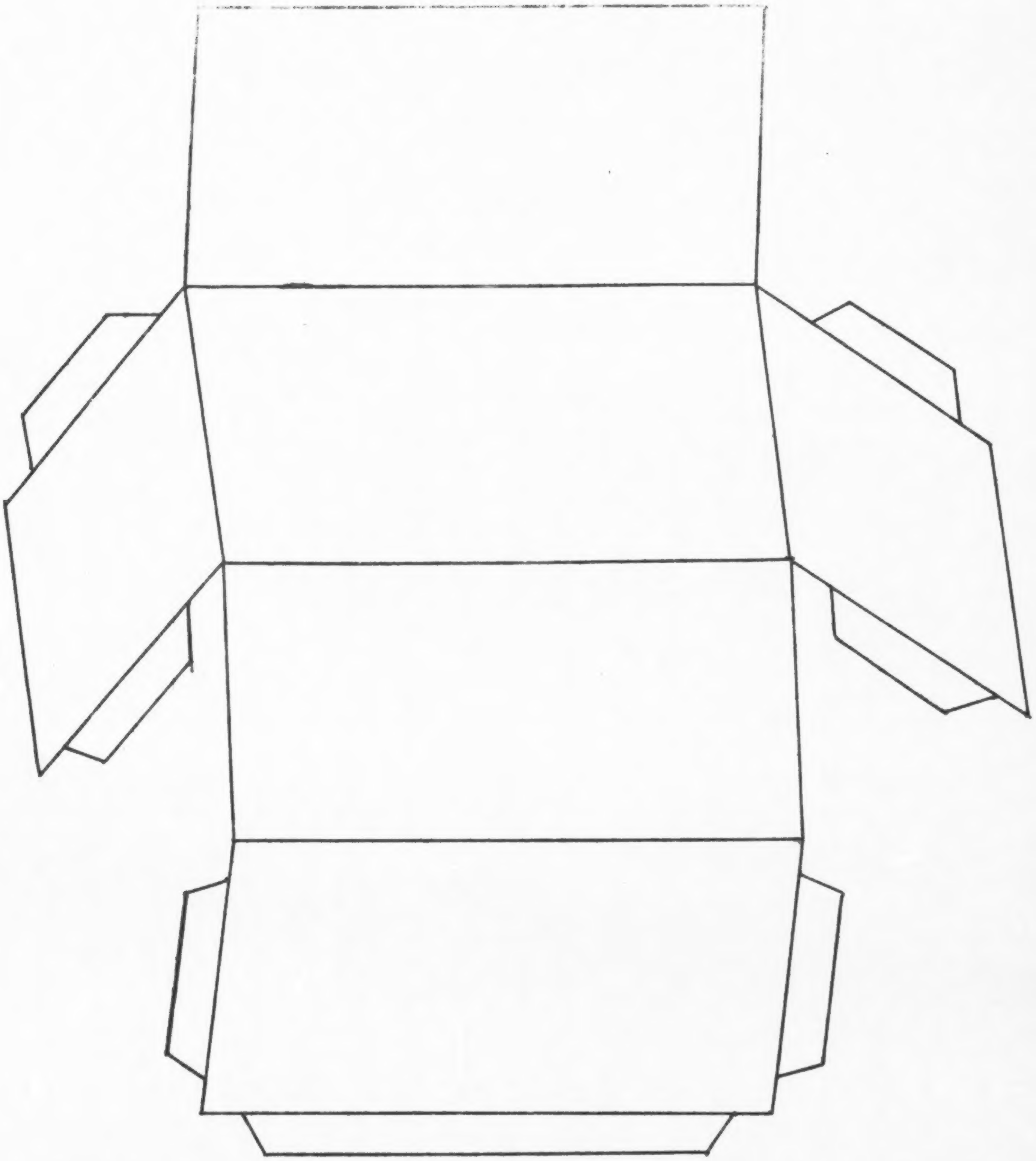
(Rhombohedral crystal form includes the mineral calcite)


UNDER E
B
E
UNDER D
A
D
C
UNDER A
UNDER C
UNDER B

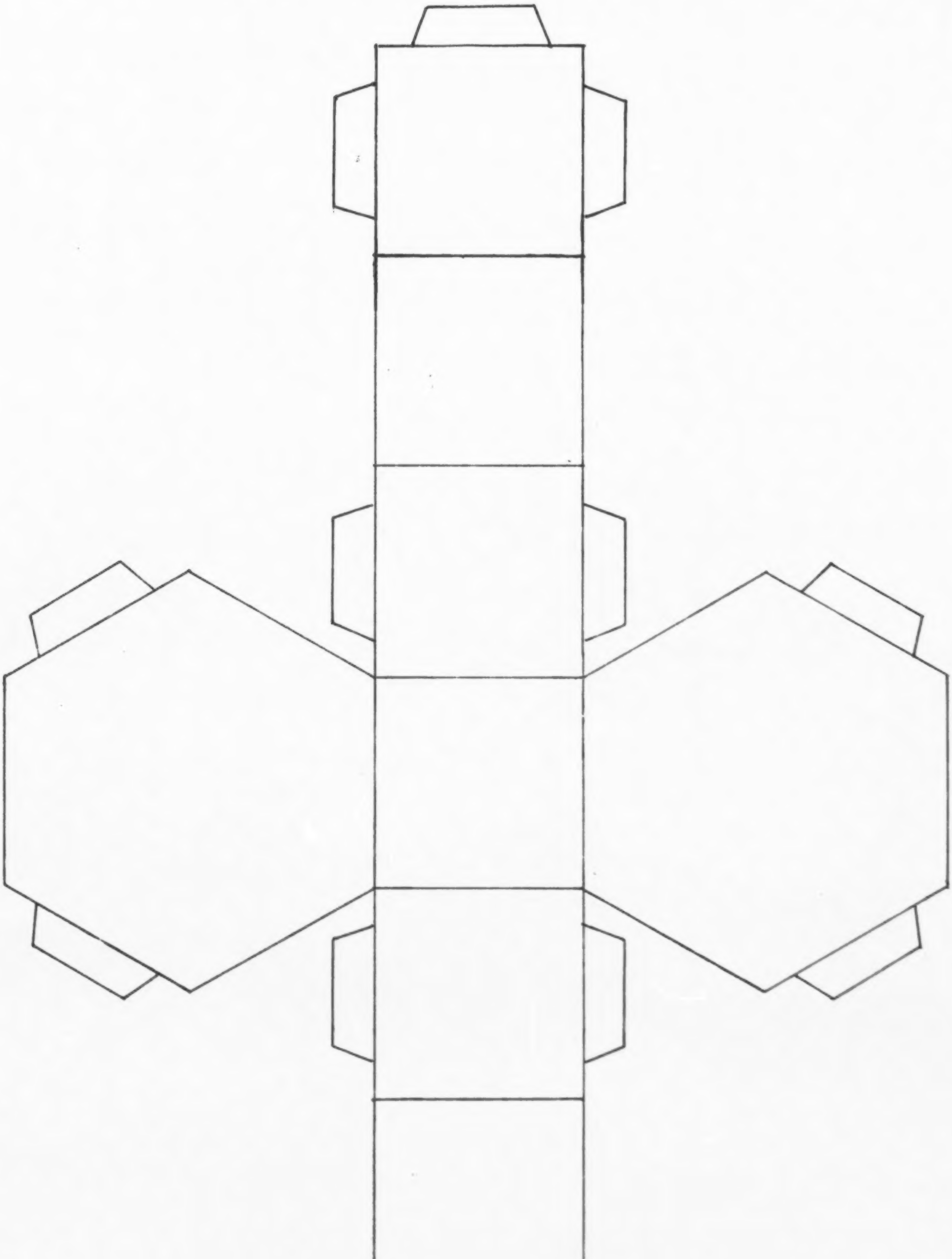
ISOMETRIC SYSTEM



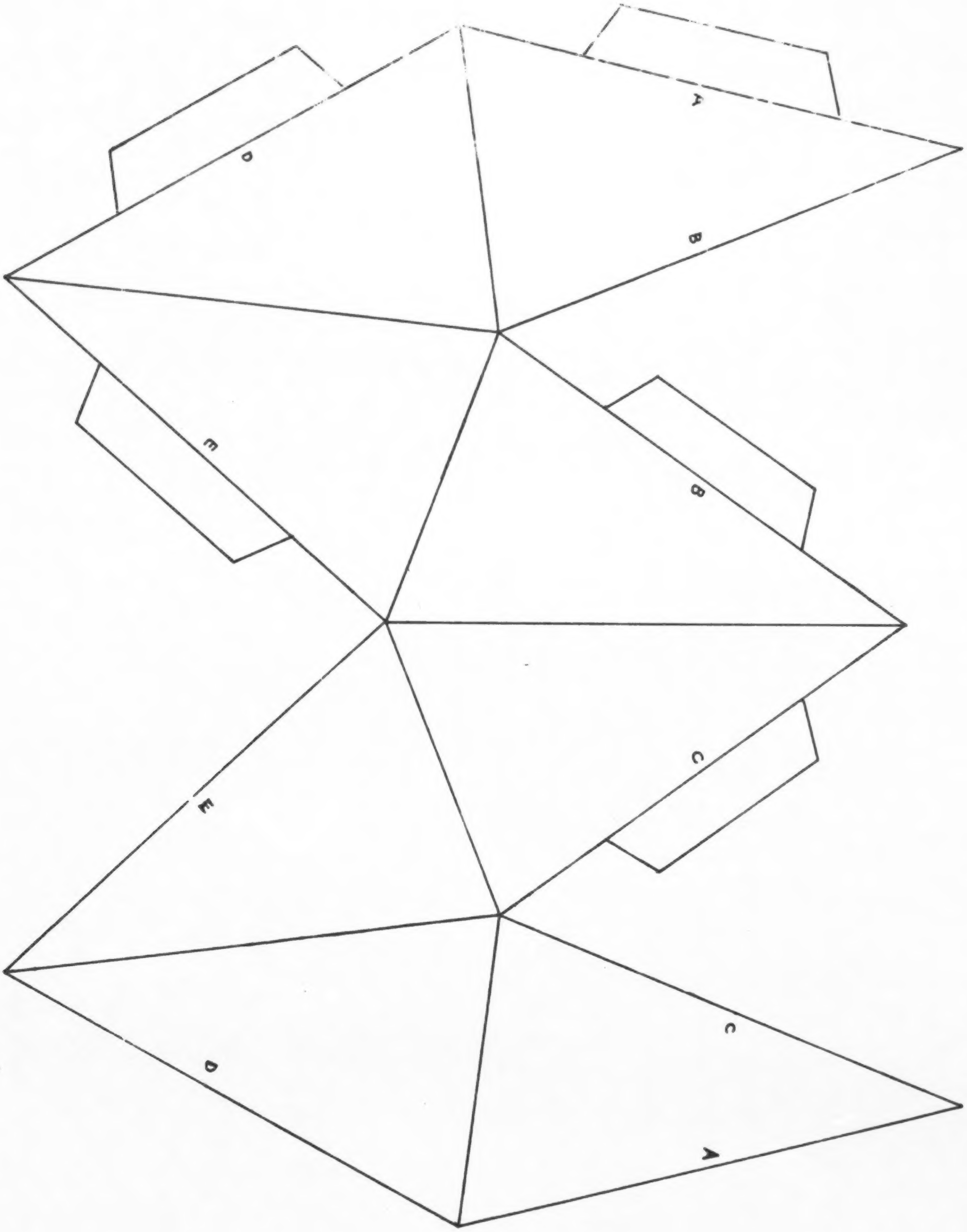
TETRAGONAL SYSTEM



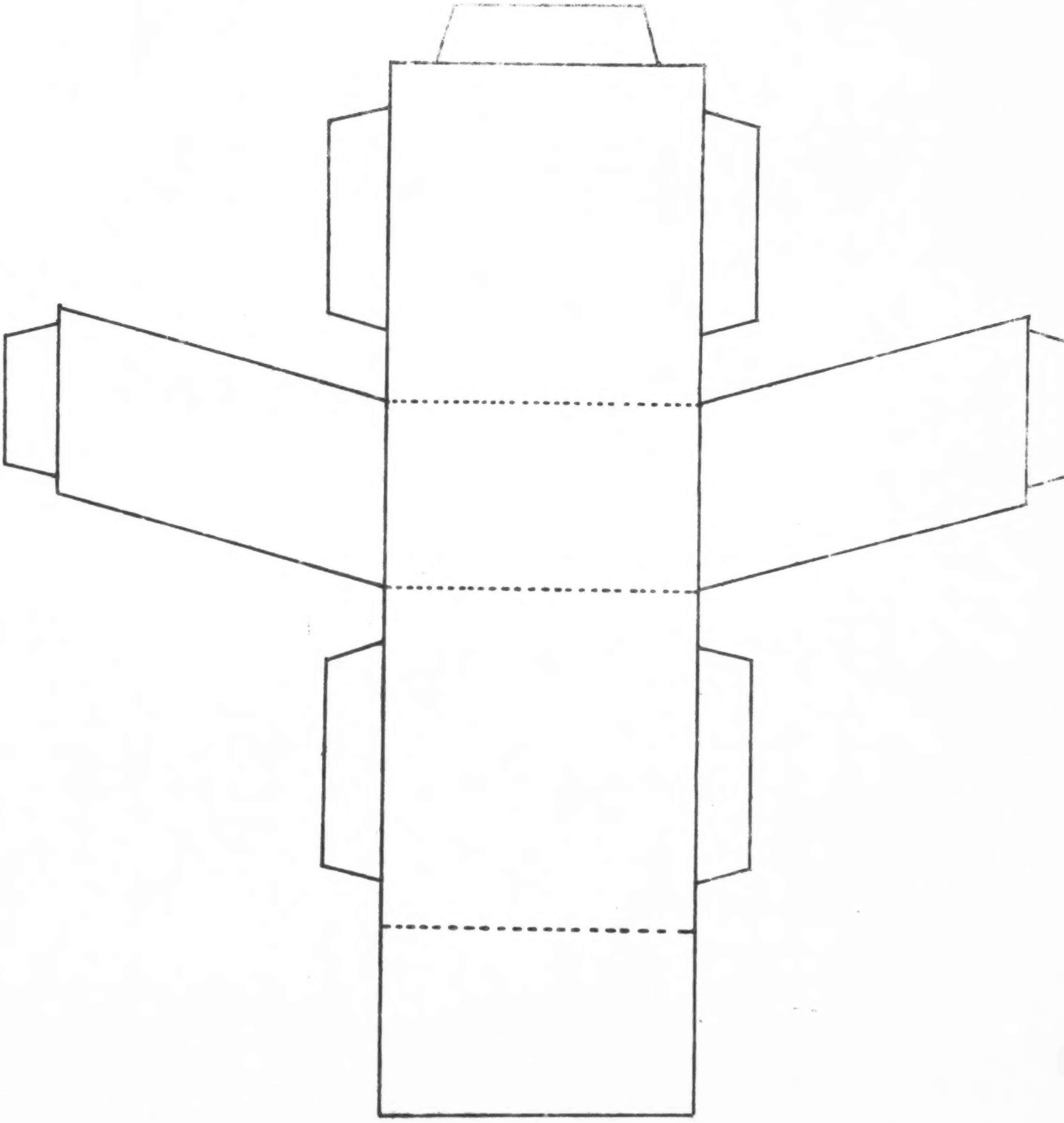
TRICLINIC SYSTEM



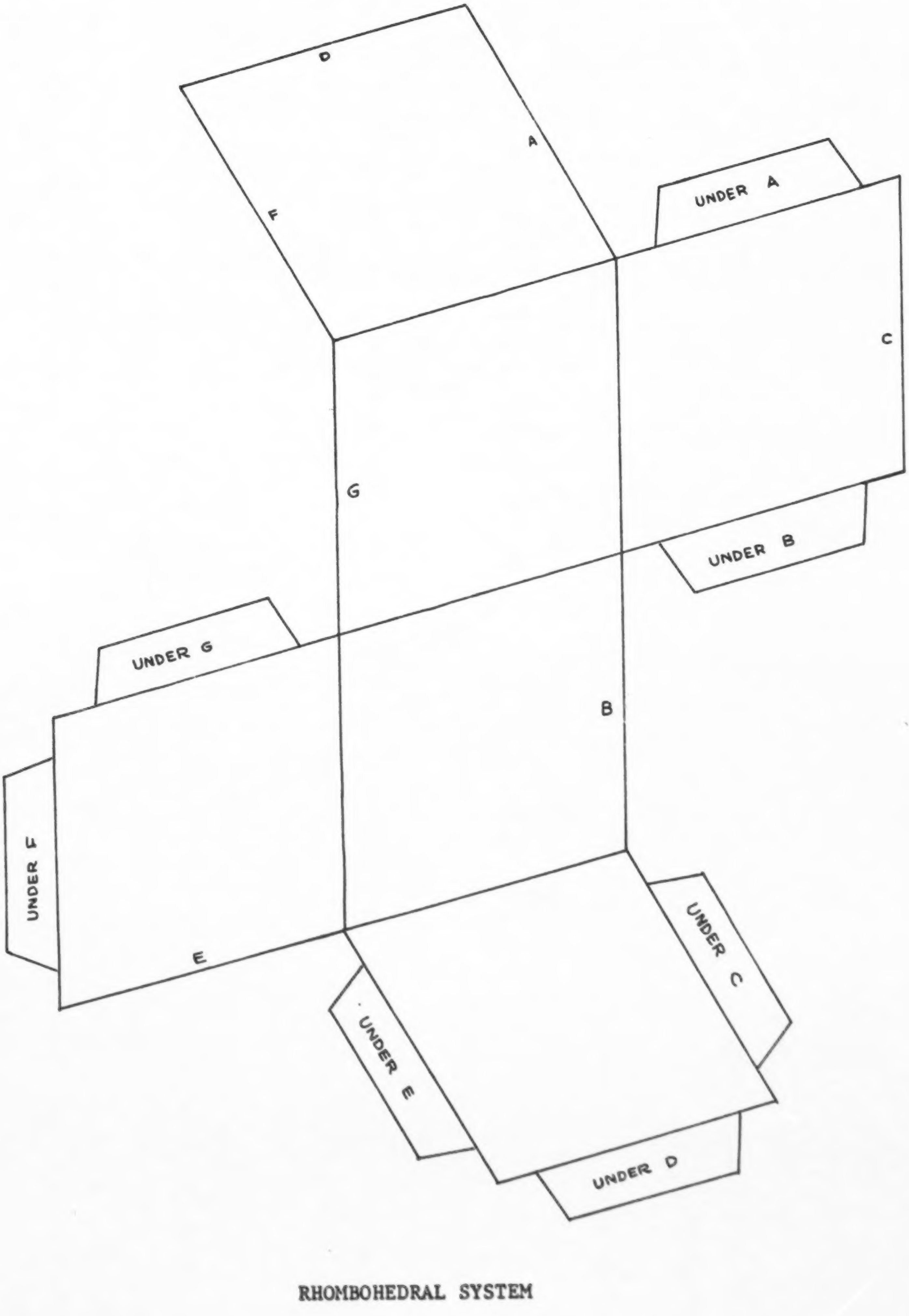
HEXAGONAL SYSTEM


A
D
B
E
B
C
E
C
D
A

ORTHORHOMBIC SYSTEM



MONOCLINIC SYSTEM


D
A
F
UNDER A
C
G
UNDER B
UNDER G
B
UNDER F
E
UNDER C
UNDER E
UNDER D

RHOMBOHEDRAL SYSTEM

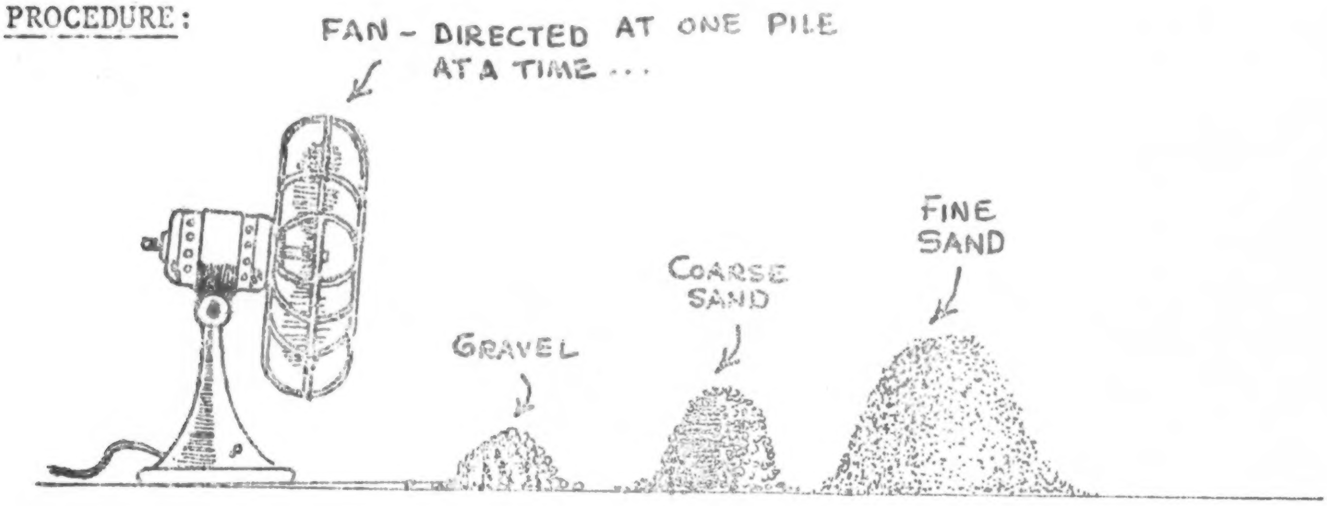
GEOLOGY

I. OBJECTIVE: To show how wind affects sand: How sand dunes are formed.

II. MATERIALS:

- A. Supply of fine sand (one bucket full)
- B. Supply of coarse sand (one bucket full)
- C. Supply of gravel (one bucket full)
- D. Electric fan and extension cord
- E. Long table with raised sides (Cardboard can be tacked, stapled or taped to form sides)
  Or, do this outside on smooth concrete.

III. PROCEDURE:


FAN - DIRECTED AT ONE PILE AT A TIME ...
GRAVEL
COARSE SAND
FINE SAND

- A. Dump each bucket of sand and gravel into separate piles on the table or concrete.
- B. Place the fan near the pile of fine sand. Turn it on and adjust so that the wind strikes the sand pile.
- C. Observe for five minutes and record the results.
- D. Repeat with the coarse sand and gravel, record the results.
- E. Mix the three piles and repeat the experiment. Record the results.
- F. Make certain that fan is placed same distance from each pile.

IV. OBSERVATIONS:

- A. What happens to the pile of fine sand?

- B. What happens to the pile of coarse sand?

- C. What happens to the pile of gravel?

- D. What happened to the mixture?

GEOLOGY

V. CONCLUSION:

A. The wind carried the fine sand further than the coarse sand due to the weight of each particle being lighter.

B. Sand is sorted into various piles or dunes by the wind, depending upon the size of the sand particles. The lighter the particle, the further the wind can carry it.

C. Gravel is not affected by the wind due to its weight. However, it could help in the formation of sand dunes by acting as a barrier for sand particles to start piling up against. Vegetation can act in the same manner.

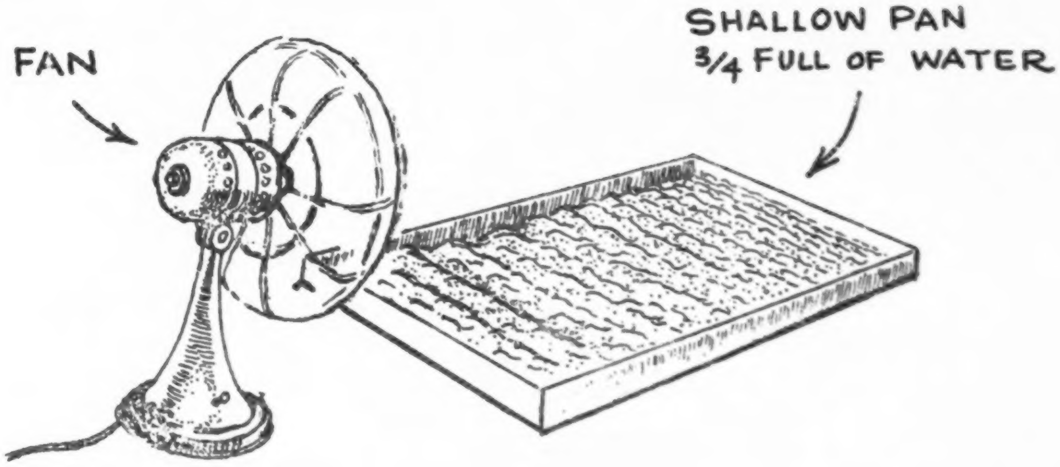
GEOLOGY

I. OBJECTIVE: To show how wind causes waves.

II. MATERIALS:

- A. Shallow pan
- B. Water
- C. Electric fan
- D. Rock

III. PROCEDURE:



- A. Fill the shallow pan about three fourths full of water.
- B. Point the fan towards one end of the pan and turn it on low speed and observe.

  DANGER: Keep fingers away from the fan blade and keep water away from the fan and cord.

- C. Now turn the fan to high speed and observe the water.
- D, Place a rock in the water and repeat the activity. How does the obstruction affect the waves?

IV. OBSERVATIONS:

- A. Small waves are formed when the fan was on low speed.
- B. Larger waves were formed when the fan was on high speed.
- C. Waves splashed against the rock on the windward side.
- D. There was a small area of relatively calm water on the leeward side side of the rock.

GEOLOGY

V. CONCLUSION:

A. Wind is responsible for most waves.

B. The size and shape of a wave is generally dependent upon the depth of the water.

C. Generally, waves affect only the surface, and in the shallows, move the sand beneath.

D. Waves are larger on the leeward side of (downwind) large bodies of water, since the wind has a chance to push the water ahead of it.

E. The distance the wind has to sweep across a body of water is known as the "fetch".

F. Coves and harbors are usually calmer than the main body of water because trees or projecting points of land help break up or slow down the action of the wind.

GEOLOGY

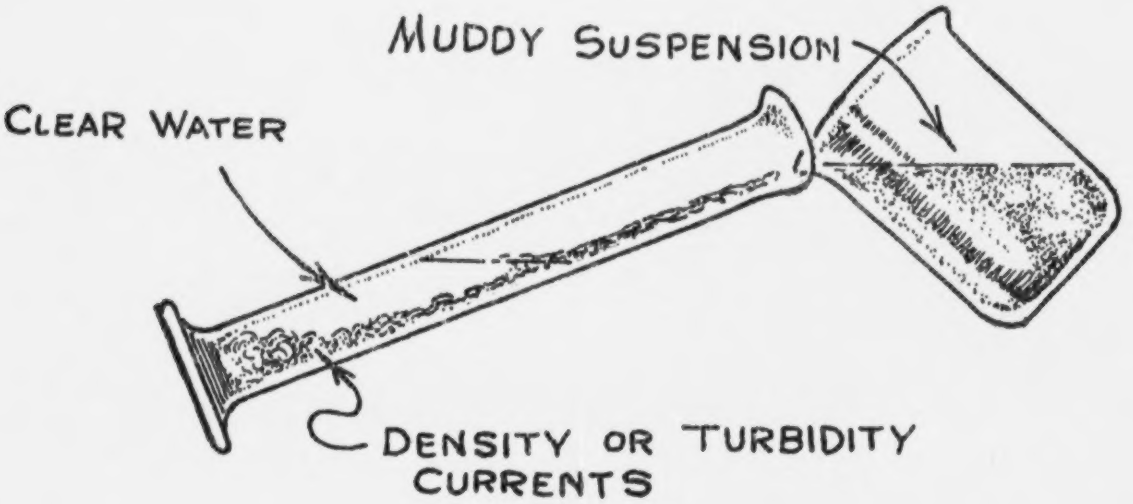
I. OBJECTIVE: To show how density or turbidity currents are formed.

II. MATERIALS:

A. Large hydrometer jar or graduated cylinder
B. Clear water
C. Sand, silt, mud
D. Beaker

III. PROCEDURE:

A. Half fill hydrometer jar or cylinder with water and position at an angle as illustrated.
B. Make a concentrated solution of fine sand, silt and mud in the beaker.
C. Carefully pour some of this solution down the bottom edge of the cylinder and observe.



IV. OBSERVATIONS:

A. The muddy solution moved to the lowest part of the cylinder, creating a rolling type of current as it moved forward.
B. The tilted cylinder represents the continental slope.
C. The muddy solution represents a denser solution that results through the mixing of mud and or silt with sea water on the continental slope.

GEOLOGY

V. CONCLUSION:

A. The muddy solution is denser than clear water, therefore it sinks to the bottom of the clear and lighter water.

B. As the denser water sinks beneath the lighter water, a density current if formed.

C. Muddiness of water is called "turbidity".

D. Density currents also result due to the excessive cooling at the poles, which causes the water to contract and become denser. Rapid evaporation in warm dry climates causes the sea water to become saltier, therefore denser.

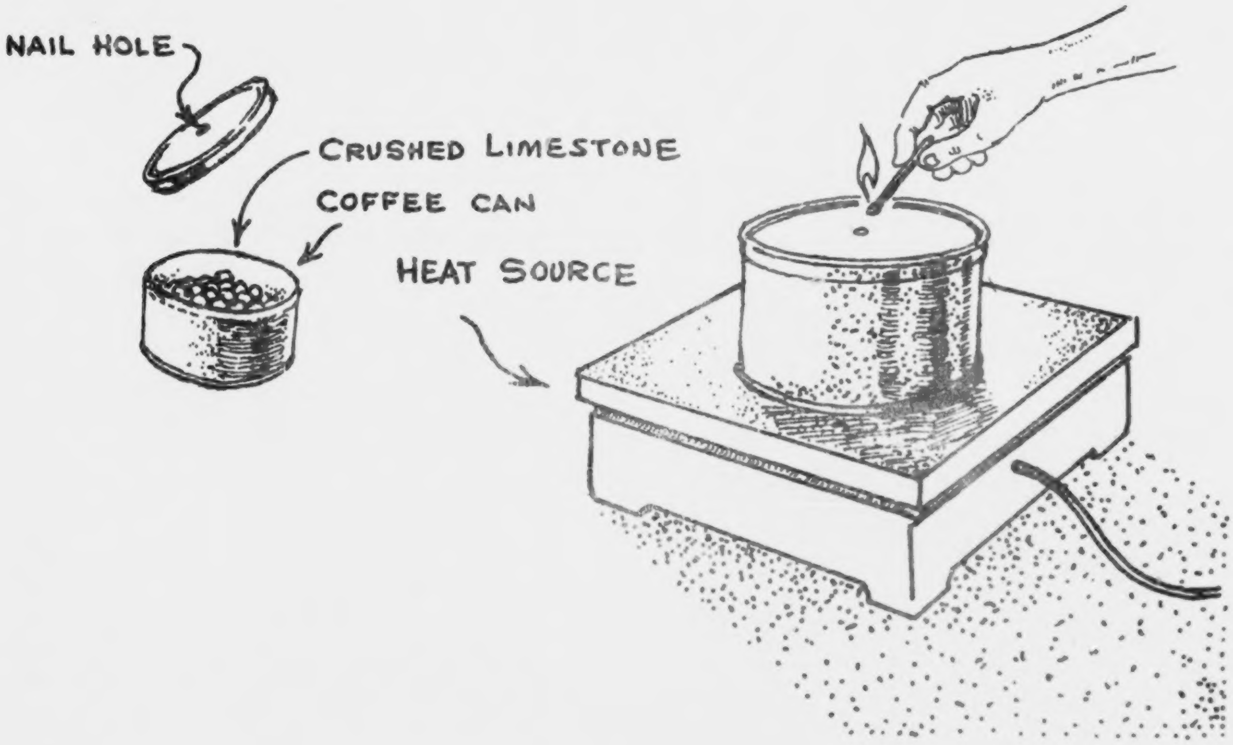
E. Many scientists believe that under-sea canyons were actually curved out of the continental slope by these density or turbidity currents.

GEOLOGY

I. OBJECTIVE: To show how lime is formed from limestone.

II. MATERIALS:

A. Pieces of crushed or broken limestone
B. Tin coffee or tobacco can with a tight cover
C. Hot plate or burner
D. Matches
E. Ringstand (if burner if used)



III. PROCEDURE:

A. With a nail, make a hole in the cover of the can.
B. Place the crushed limestone about one inch deep in the can and heat.
C. Watch hole to see if any gases are released that are visible.
D. Every five minutes light a match and hold it over the hole. What happens?
E. Continue heating until nothing happens to the lighted match.
F. When the can is cool, open an examine the contents.

IV. OBSERVATIONS:

A. No visible gas could be observed escaping through the hole.
B. The flame of the lighted match went out when held above the hole.
C. The contents of the can are now whiter and more powdery than prior to heating.

V. CONCLUSION:

A. Limestone is calcium carbonate ($CaCO_3$)
B. Lime is calcium oxide (CaO) ---- It is whiter and more easily powdered.
C. When the limestone was heated, carbon dioxide (CO_2) was driven off causing the lighted match to go out when held directly over the hole in the can.

It can be expressed or shown by a chemical formula as follows:

$$CaCO + Heat \longrightarrow \overset{\nearrow}{CO2} + CaO$$

ADDITIONAL INVESTIGATION:

A. Try to dissolve some of the contents of the can in water.

B. Filter the solution through filter paper, blotting paper or paper towel.

C. By blowing your breath through a straw into the filtered liquid, you can tell if you have made some limewater.

GEOLOGY

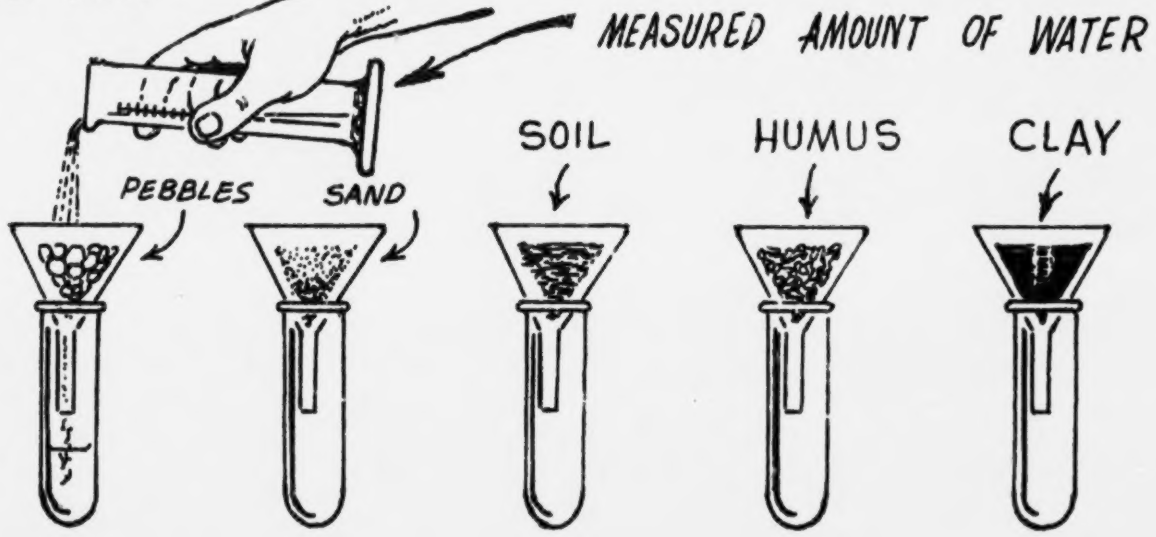
I. OBJECTIVE: To demonstrate and explain permeability

II. MATERIALS:

A. Pebbles
B. Sand
C. Soil
D. Humus (Black dirt)
E. Clay (If natural clay is not available, use modeling clay.)
F. Four glass funnels
G. 6 test tubes
H. Watch

III. PROCEDURE:

A. Fill each funnel within 3/4 inch of the top with pebbles, sand, soil, humus, and clay.
B. Set the stem of each funnel into a test tube.
C. One at a time, pour a test tube of water into each funnel, carefully measuring the time required for the water to flow down into the lower test tube.



IV. OBSERVATIONS:

A. The water flows through the materials in this order:
   1. Pebbles ----very rapidly
   2. Sand -------rapidly
   3. Soil -------slowly
   4. Humus ------very slowly
   5. Clay -------hardly any flow

V. CONCLUSION:

A. Permeability -- the ease with which water can flow through soil or rock substance.
B. The permeability of a substance depends upon the size of the particles of that substance.----The larger the particles, the greater the permeability.
C. NOTE: Materials like clay may be highly porous, yet be impermeable due to the very fine pores. Nonporous rocks such as limestone often become permeable due to the formation of cracks and fissures through which water can pass freely.

GEOLOGY

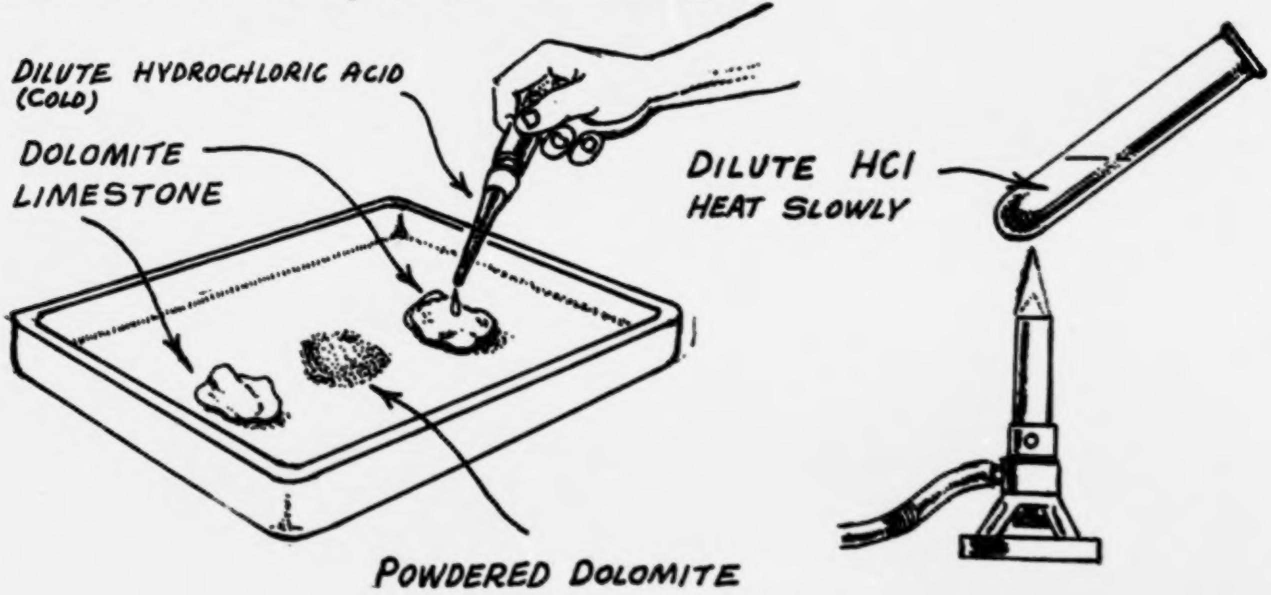
I. OBJECTIVE: Simple acid test for limestone and dolomite.

II. MATERIALS:

A. A sample of limestone
B. A sample of dolomite
C. Dilute hydrochloric acid --- four parts of water to one part HCl
D. Glass tray or dish
E. Source of heat
F. Hammer
G. Test tube and test tube clamp
H. Anvil or piece of railroad rail

III. PROCEDURE:

A. With the specimens in the glass dish, place a drop or two of the dilute hydrochloric acid on each. Record any reaction.
B. VERY CAREFULLY heat the dilute HCl in the test tube and place a drop or two of the warm acid on the sample that did not react with the cold acid. Record any reaction.
C. Break off a small piece of the specimen that did not react with the cold acid. Crush it to a powder and test it with dilute hydrochloric acid. Record any reaction.
D. Check each of the specimens for hardness.


DILUTE HYDROCHLORIC ACID (COLD)
DOLOMITE
LIMESTONE
DILUTE HCl HEAT SLOWLY
POWDERED DOLOMITE

GEOLOGY

IV. OBSERVATIONS:

A. Limestone reacts --- (fizzes) with dilute hydrochloric acid. Dolomite does not.

B. Dolomite reacts with the acid when crushed to a powder.

C. Dolomite reacts with warm dilute hydrochloric acid.

D. Dolomite is slightly harder than limestone ---3.5 to 4.0

V. CONCLUSION:

A. Limestone and dolomite can be identified by the simple acid test.

B. A lump specimen of limestone reacts with cold dilute HCl. Dolomite does not.

C. Dolomite will react with dilute warm HCl.

D. Dolomite powder or dust will react with cold dilute HCl.

E. Limestone (calcium carbonate -- $CaCO_3$) has a hardness of 3.0. Dolomite (calcium magnesium carbonate -- $CaMg\,(CO_3)_2$ has a hardness of 3.5 to 4.0.

GEOLOGY

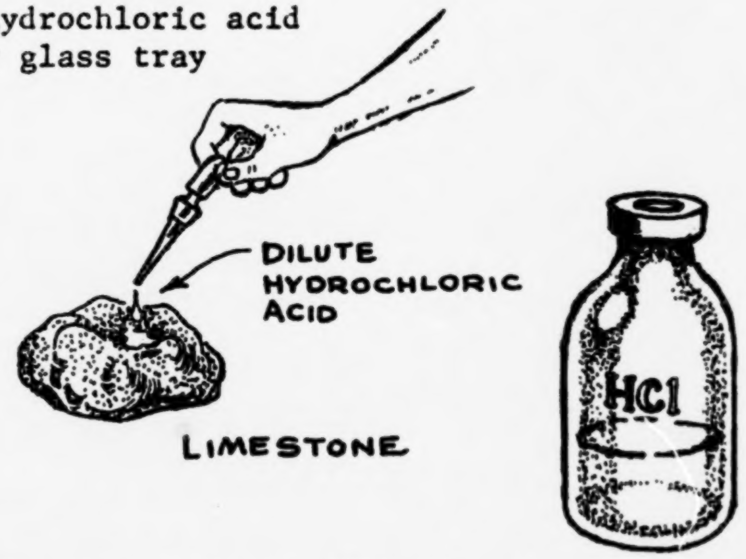
I. OBJECTIVE:

To show how caves and sinkholes are formed in limestone layers.

II. MATERIALS:

A. Piece of limestone
B. Dilute hydrochloric acid
C. Metal or glass tray

III. PROCEDURE:



A. Place a few drops of the diluted acid on the piece of limestone. What happens?
B. Continue putting more acid in the same spot.
C. Observe this same spot closely after washing the specimen thoroughly.

IV. OBSERVATIONS:

A. The limestone fizzed upon contact with the dilute hydrochloric acid.
B. A small depression was formed as the acid was continually added to the same spot.

V. CONCLUSION:

A. Most large caves are formed in layers of limestone.
B. Rainwater dissolves carbon dioxide from the air, forming a weak carbonic acid.
C. As this rainwater seeps through the cracks and crevices of limestone layers, it reacts chemically with the limestone it contacts, slowly dissolving some of the limestone as it moves downward.
D. Eventually holes are formed in the rock.
E. If they are near the surface, the roofs may collapse and form sinkholes.
F. Caves or caverns usually develop in limestone that is capped with harder rock in the region above.

GEOLOGY

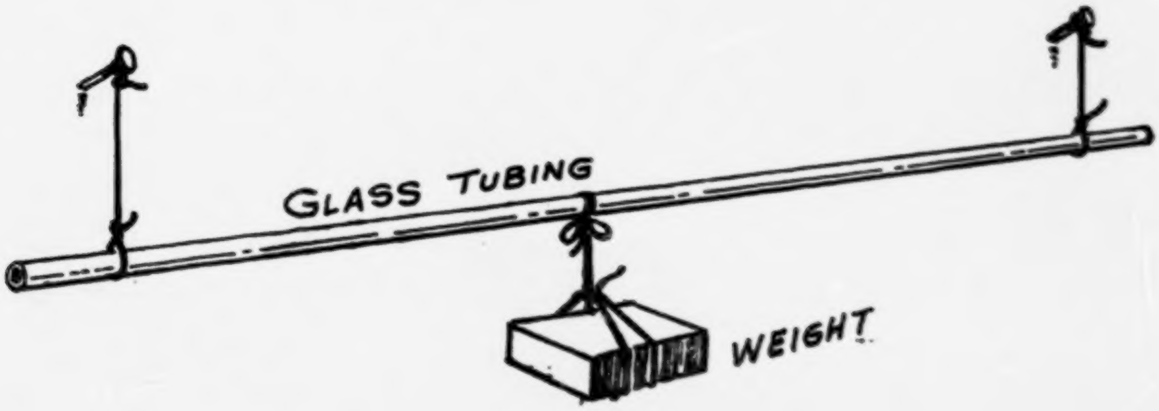
I. OBJECTIVE: To demonstrate how rock formations are warped without breaking.

II. MATERIALS:

- A. String
- B. A weight
- C. Piece of glass rod, three feet or longer

III. PROCEDURE:

- A. Suspend tubing by strings as indicated in the drawing.
- B. Hang a small weight from the center of the tubing.
- C. Allow to remain hanging for two weeks and inspect the tubing.



IV. OBSERVATIONS:

- A. The piece of glass tubing was straight prior to being suspended.
- B. At the end of the two weeks, the tubing has a slight bend in it.

V. CONCLUSION:

- A. The steady pressure exerted by the weight over the two week period of time caused the glass tubing to bend rather than break.
- B. Considerable pressure is constantly being exerted on rock formations below the earth's surface. This generates heat and over a period of thousands or millions of years, solid rock layers are bent, folded and cracked.

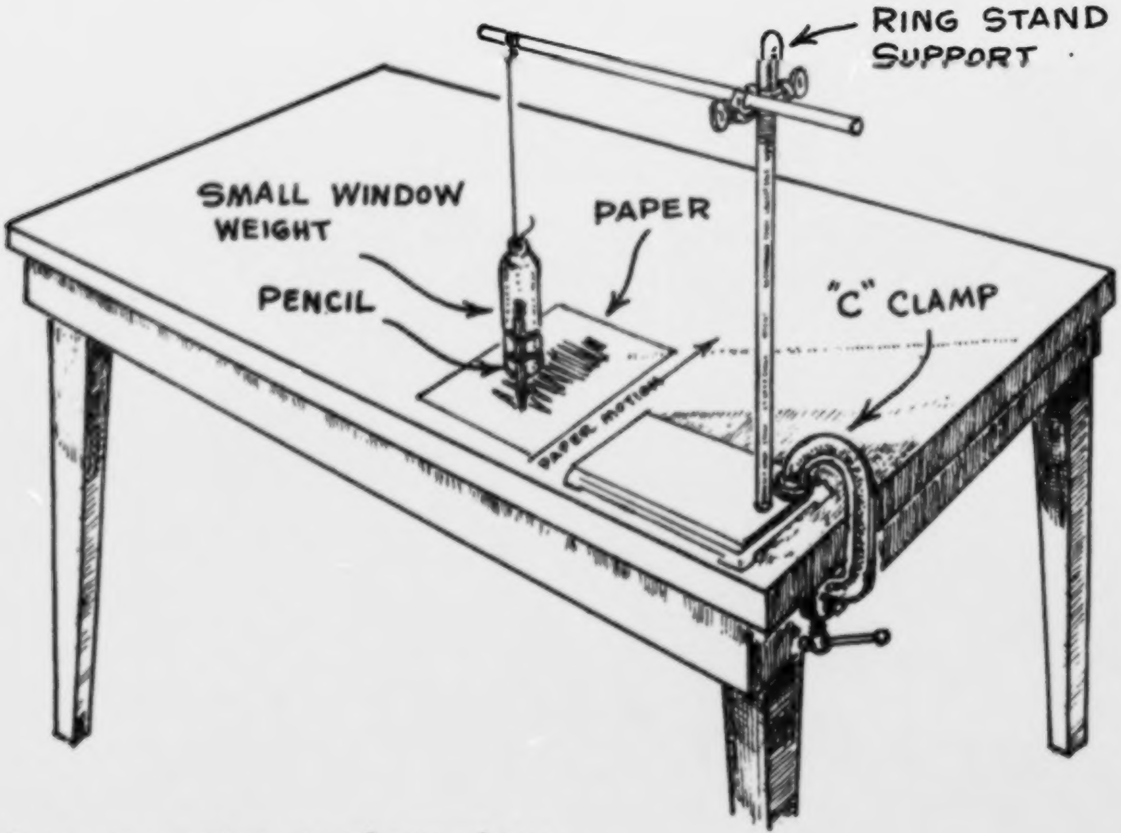
GEOLOGY

I. OBJECTIVE: To construct a model seismograph.

II. MATERIALS:

- A. Window weight or other suitable weight
- B. Pencil
- C. Tape
- D. Paper
- E. Ring stand support and ring.
- F. "C" clamp

III. PROCEDURE:


RING STAND SUPPORT
SMALL WINDOW WEIGHT
PAPER
PENCIL
"C" CLAMP
PAPER MOTION

- A. Set up apparatus as shown above.
- B. Pencil should be just touching the paper.
- C. Jar table lightly and observe.
- D. Jar table more severely and observe.

IV. OBSERVATIONS:

A. The weight moved back and forth slightly when the table was tapped gently, causing short tracings to appear on the paper.

B. The weight moved back and forth further when the table was jarred more severely, causing the pencil to make longer tracings on the paper.

V. CONCLUSION:

A. A seismograph is a free-hanging pendulum, held steady in its vertical plane by the weight.

B. It is mounted in concrete which in turn rests on solid rock below ground level.

C. As rock layers shift and cause vibrations (earthquakes), the intensity of the vibrations can thus be measured by means of a seismograph.

D. The tracing (recording) made by a seismograph is called a seismogram.

E. The device illustrates the principle of a seismograph. There are other types.

WEATHER

CONTENT:

INTRODUCTION

VOCABULARY

CONCEPT

What causes air pressure?

Why does air pressure decrease as you go higher above sea level?

To show that air occupies space.

To show that air occupies space.

To show that air does have weight.

To show and explain the effects of air pressure.

To show that air exerts pressure.

To show that air pressure is essential to drink with a straw.

The siphon and how it uses air pressure and gravity to work.

To show that air expands when heated.

Dark objects absorb more heat than light or shiny objects.

To show that the air is heated by contact with land and water.

Making a cloud in a jug and explaining what causes this to happen.

To show how a tornado is formed and the direction of winds in a tornado.

WEATHER

I. INTRODUCTION:

A. Weather: The condition of the atmosphere at a given place and time.

B. Atmosphere: The ocean of air that surrounds the earth.

C. Condition of the Atmosphere:

I. Hot or cold -- temperature -- measured by thermometer.

2. Wet or dry -- relative humidity (air moisture)-- hygrometer or sling psychrometer.
Precipitation: (melted) Rain -- Hail -- Snow -- Sleet.

3. Windy or calm -- air movement

(a) Velocity --- anemometer
(b) Direction -- wind vane

4. Clouds --- type and amount -- observed and determined visually

5. Air pollution -- dust, smoke, etc.

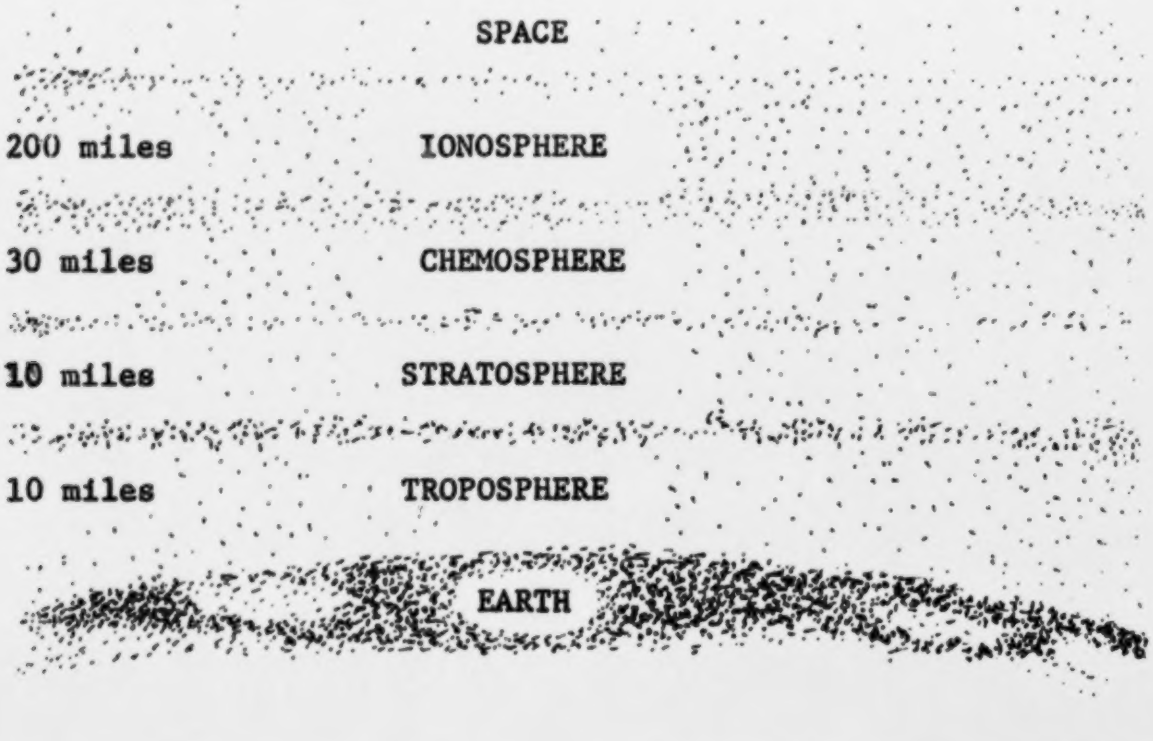
6. Air pressure -- normal is 14.7 pounds per square inch at sea level.

(a) Seldom normal due to:

(1) Elevation above sea level
(2) Per cent of water vapor in the air
(3) Temperature of the air

(b) BAROMETER: Indicates changes in air pressure

D. LAYERS OF THE ATMOSPHERE:


SPACE
200 miles
IONOSPHERE
30 miles
CHEMOSPHERE
10 miles
STRATOSPHERE
10 miles
TROPOSPHERE
EARTH

WEATHER

I. OBJECTIVE:

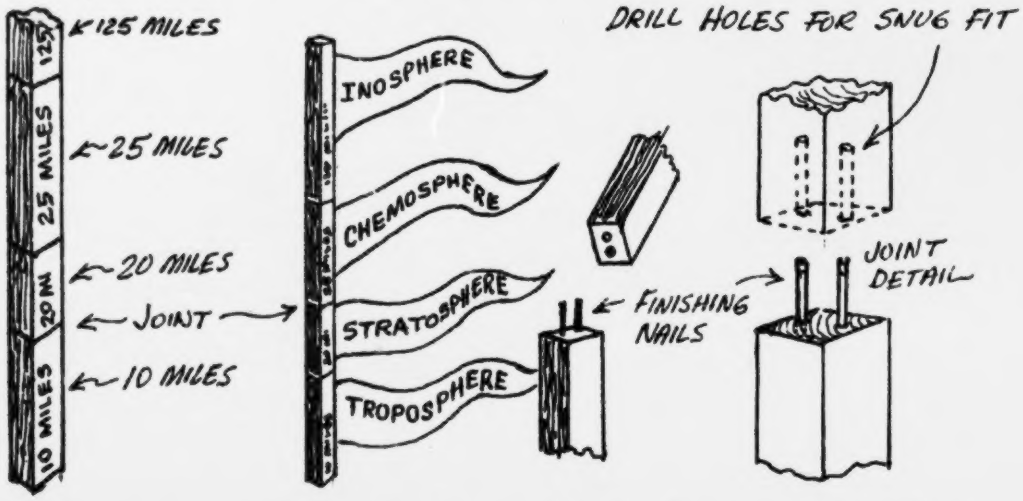
What causes air pressure?
Why does air pressure decrease as you go higher above sea level?

II. MATERIALS:

- A. Poster board
- B. Magic Marker pen
- C. Piece of lumber - 1" x 1" x 8 feet long
- D. Paint

III. PROCEDURE:

- A. Cut out pennants and label for the four layers of the atmosphere -- making certain all print can be read from all parts of the room.
- B. Cut 8' piece of lumber into 2 pieces 1' in length, one piece 2' in length and the remainder would be 4' long.
- C. Using finishing nails as pins, make the arrangement illustrated below so that the 4 pieces can be joined and detached easily.
- D. Paint each of the 4 sections a different color.


125
25 MILES
20 MI
10 MILES
125 MILES
25 MILES
20 MILES
JOINT
10 MILES
INOSPHERE
CHEMOSPHERE
STRATOSPHERE
TROPOSPHERE
DRILL HOLES FOR SNUG FIT
FINISHING NAILS
JOINT DETAIL

IV. OBSERVATIONS:

- A. This one inch column represents a column of air from sea level to the very top of the atmosphere.
  - 1. If it were physically possible to do so, a one inch square column of air placed on a scale would weigh 14.7 pounds, --- thus the 14.7 pounds per square pressure inch at sea level is the result of the weight of this column of air.
  - 2. 75% of this weight is in the troposphere, that portion of the atmosphere in which we live. (about 11 pounds) This is due to the fact that the molecules of air are much closer together in the troposphere. In fact, the higher one goes up in the atmosphere, the further apart the molecules are spread.

V. CONCLUSION:

There are numerous ways in which this rod, representing a one square inch column of air, can be utilized when teaching about air pressure, atmosphere and its layers, etc.

WEATHER

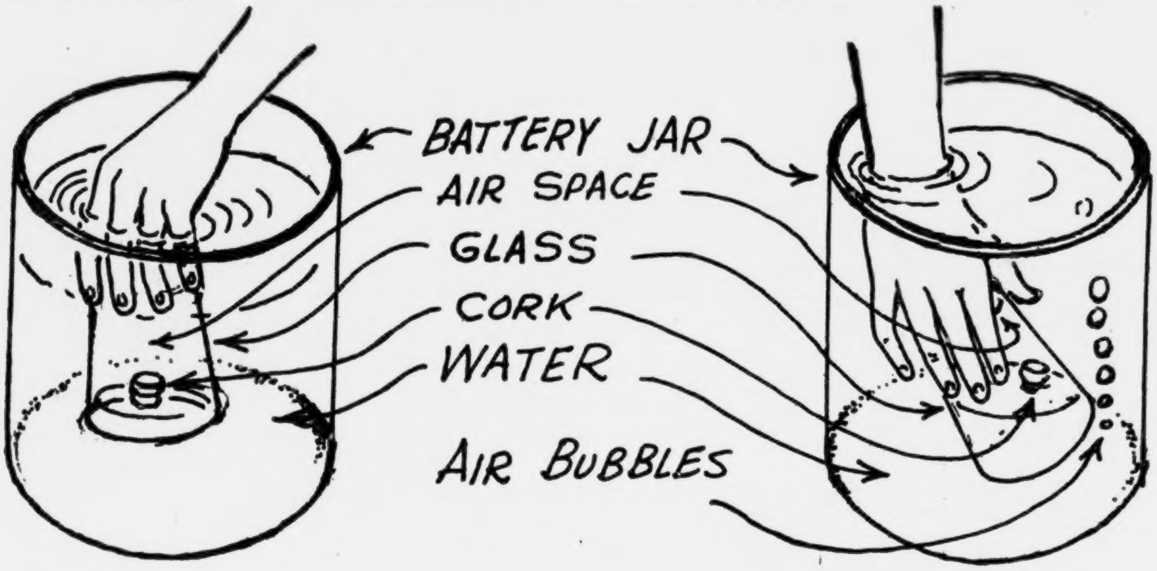
I. OBJECTIVE: To show that air occupies space.

II. MATERIALS:

A. Glass or beaker
B. Large battery jar
C. Small cork

III. PROCEDURE:

A. Fill battery jar about half full of water
B. Place cork on the water
C. Push "empty" inverted glass into the water over the cork -- Observe
D. Now, tip glass to one side:----- What happens?



IV. OBSERVATIONS:

A. The cork floated on a layer of water inside the glass, but below the level of the water in the battery jar.
B. When the glass was tilted to one side, bubbles appeared and water entered the glass.

V. CONCLUSION:

A. The fact that the water level and cork inside the inverted glass was lower than the level of the water in the battery jar shows that the glass was not really, ---it contained air and air does occupy space.
B. When the glass was tipped, the air escaped as indicated by the bubbles, and the air was replaced by the water.
C. Air does occupy space.

WEATHER

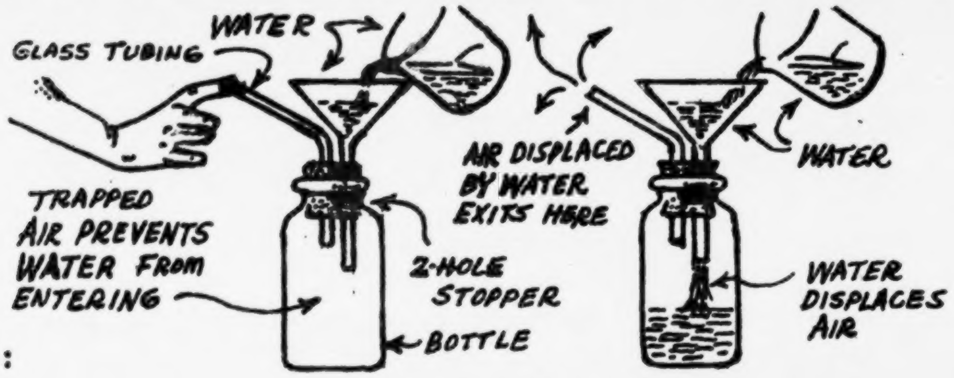
I. **OBJECTIVE:** To show that air occupies space.

II. MATERIALS:

A. Bottle or flask
B. Two-hole stopper to fit A
C. Glass funnel to fit stopper
D. Beaker
E. Water

III. PROCEDURE:

A. Using soap (liquid) as a lubricant, insert funnel into stopper
B. Insert stopper with funnel into flask
C. Fill beaker about half full of water
D. Have one child hold finger tightly over uncovered hole while another pours water in the funnel to fill the flask.
E. Now have the child remove his finger from the uncovered hole.


WATER
GLASS TUBING
TRAPPED AIR PREVENTS WATER FROM ENTERING
2-HOLE STOPPER
BOTTLE
AIR DISPLACED BY WATER EXITS HERE
WATER
WATER DISPLACES AIR

IV. OBSERVATIONS:

A. Water would not enter flask from the funnel while hole was covered.
B. As soon as the hole was uncovered, water entered flask from the funnel.

V. CONCLUSIONS:

A. Water did not enter the flask because the air in the flask could not escape, thus the air held the water back.
B. When the second child removed his finger from the hole, the air then could escape, allowing the water to enter and take the place of the air.
C. AIR DOES OCCUPY SPACE.

WEATHER

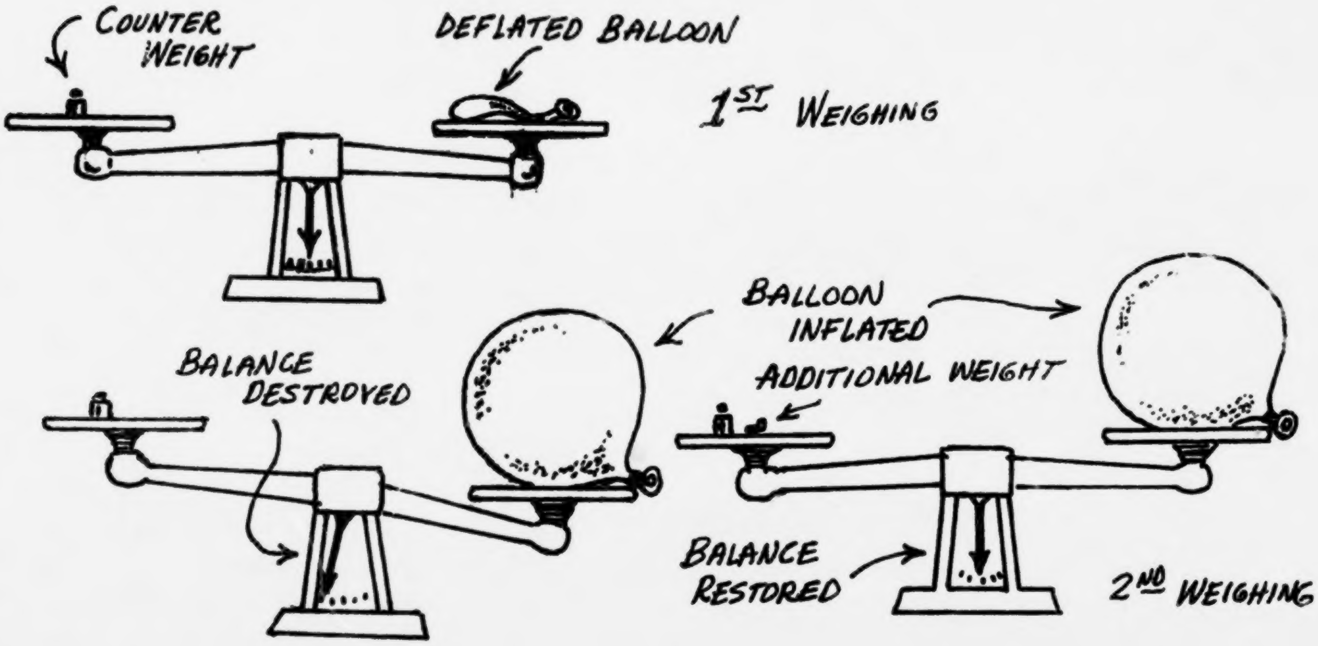
I. OBJECTIVE: To show that air does have weight

II. MATERIALS:

A. Large balloon
B. Tire pump
C. Balance

III. PROCEDURE:

A. Weigh balloon in deflated condition
B. Using the tire pump, inflate balloon
C. Re-weigh the balloon


COUNTER WEIGHT
DEFLATED BALLOON
1ST WEIGHING
BALLOON INFLATED
BALANCE DESTROYED
ADDITIONAL WEIGHT
BALANCE RESTORED
2ND WEIGHING

IV. OBSERVATIONS:

A. Balloon before inflation weighed ____________________
B. Balloon after inflation weighed ____________________

V. CONCLUSION:

A. The balloon weighed more after inflation
B. This shows that air does have weight
C. Since air does have weight and does occupy space, AIR IS MATTER.

WEATHER

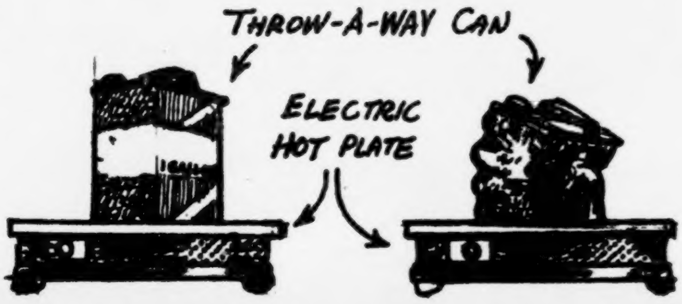
I. **OBJECTIVE:** To show and explain the effects of air pressure.

II. **MATERIALS:**

A. Empty and clean one or two gallon oil or gas can. (disposable type)
B. Gas burner or electric hot plate
C. Small amount of water

III. **PROCEDURE:**

A. Place small amount of water in the can. Place over source of heat and allow the water to boil for several minutes.
B. Explain that the purpose of the water is to prevent the can and solder from melting.
C. Explain that as air is heated, it becomes lighter and rises.
D. Explain that there are approximately 200 square inches, top and bottom not included, exposed on the average one gallon duplicator fluid can whose dimensions are 4 inches thick, 6-1/2 inches wide and 9-1/2 inches high. This figures out to a total of 3,940 pounds -- almost 2 tons. Considerably heavier than the average American Automobile. The reason the can does not collapse normally is the fact that this pressure is exerted equally in all directions - outside in -- inside out -- up, down, etc.
E. After the water has boiled for several minutes, remove the can from the heat source, replace the cap tightly and observe.



IV. **OBSERVATIONS:**

A. Can remained normal while being heated
B. Condensed steam could be seen over the opening of the can.
C. Shortly after the cap was replaced tightly, the can twisted and collapsed.

V. **CONCLUSION:**

A. As the can was heated, the air became lighter and rose from the can creating a partial vacuum inside the can.
B. Due to the greater air pressure on the outside of the can, the can collapsed shortly after the cap was replaced.
C. The can did not collapse prior to this because the can was open and the air pressure could equalize itself --- but, as soon as the cap sealed off the outside air, and the small amount of air remaining in the can began to contract, the can then began to collapse.

WEATHER

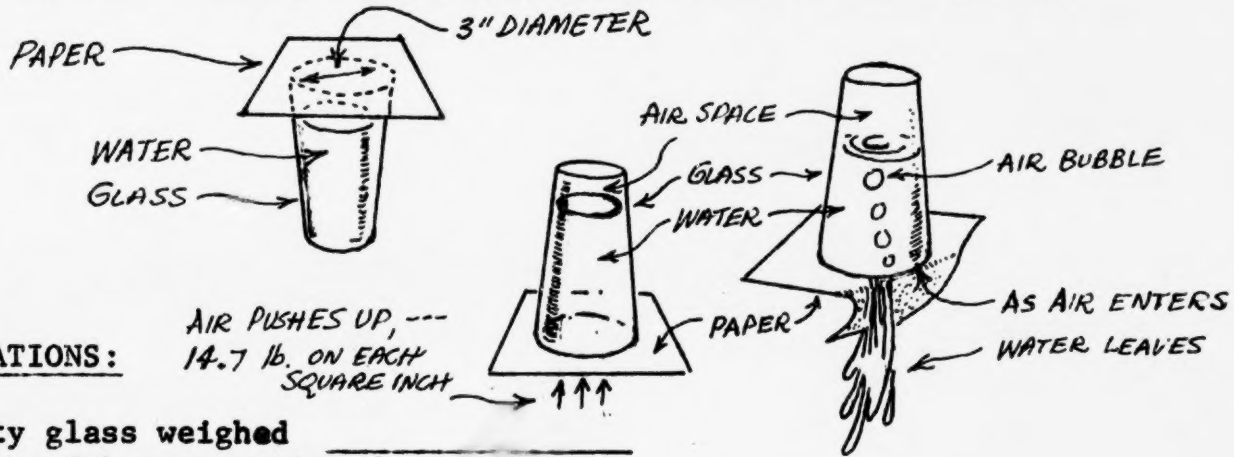
I. OBJECTIVE: To show that air exerts pressure.

II. MATERIALS:

A. Glass or jar with smooth, even rim, --- a beaker will not work
B. Balance
C. Water
D. Ditto paper
E. Pan or sink

III. PROCEDURE:

A. Weigh empty glass
B. Fill glass with water and weigh
C. Place paper over rim of glass, making certain of contact all around.
D. Holding paper firmly against rim, invert glass over the sink or large pan.
E. Remove hand from the paper and observe -- ask students to explain why!
F. Gently lift one edge of the paper and observe inside glass.



IV. OBSERVATIONS:

A. Empty glass weighed ________________
B. Glass with water weighed ______________
C. Weight of water is ______________
D. Paper remained in contact with the glass rim and the water did not fall out when the glass was inverted.
E. Large air bubbles entered the glass and the water ran out when an edge of the paper was lifted from the rim of the glass.

V. CONCLUSION:

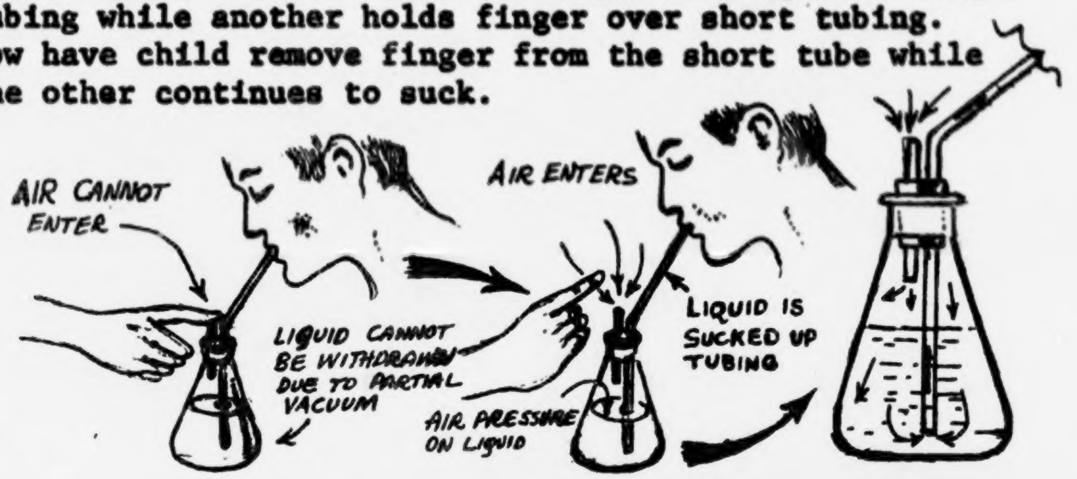
A. Air pressure held the paper in place and kept the water from running out.
   1. Air pressure at sea level is 14.7 pounds per square inch
   2. Radius squared times pi equals area of a circle
   3. A glass with a 3 inch rim has an area of about 7 sq. inches --total pressure on this area is about 103 pounds -- compare this with weight of water.
B. This would not work on a jug or small necked bottle since the area of the opening is small and the weight of the water would be greater than the total pressure on the paper covering the opening.

WEATHER

I. **OBJECTIVE**: Air pressure is essential to drink with a straw.

II. **MATERIALS**:
- A. Flask or bottle
- B. Two hole stopper to fit A
- C. One short piece of glass tubing
- D. One longer piece tubing with bend as illustrated.

III. **PROCEDURE**:
- A. Assemble as illustrated
- B. Use liquid soap when fitting stopper with glass tubing
- C. Have one child try to suck the liquid through the longer tubing while another holds finger over short tubing.
- D. Now have child remove finger from the short tube while the other continues to suck.


AIR CANNOT ENTER
AIR ENTERS
LIQUID CANNOT BE WITHDRAWN DUE TO PARTIAL VACUUM
LIQUID IS SUCKED UP TUBING
AIR PRESSURE ON LIQUID

IV. **OBSERVATION**:

- A. The liquid could not be withdrawn as long as the short tubing was closed
- B. When finger was removed from the short tubing, the liquid could then be withdrawn by sucking.

V. **CONCLUSION**:

- A. In order to drink from a container with a straw, it is essential that air from outside can enter the container to force the liquid up and through the straw.
- B. When you suck on the straw,you remove the air from the straw, creating a partial vacuum in the straw, --- then the normal air pressure on the liquid forces it up through the straw, and into your mouth.
- C. If air cannot enter to replace the space occupied by the liquid, then a partial vacuum results in the container.

NOTE: This experiment can also be effectively demonstrated with a half pint wax carton. In an unopened carton, punch a hole with an ice pick and fit with straw --- seal around outside of straw with wax and have a student attempt to suck milk from carton. If carton is air tight, this will be practically impossible.

WEATHER

I. **OBJECTIVE:** The siphon and how it uses air pressure and gravity to work.

II. MATERIALS:

A. Long piece rubber or plastic tubing
B. Large battery jar, aquarium, bucket, etc.
C. Large container or sink to catch water in

III. PROCEDURE:

A. Fill battery jar with water and place in a higher position than the sink or bucket that will be used to catch the water.
B. Now fill the tubing with water as illustrated in "A"
C. Hold both ends of tubing closed with fingers and submerge one end in container to be emptied, --- the other end in the sink or catch bucket.
D. Remove fingers from each end of the tubing.

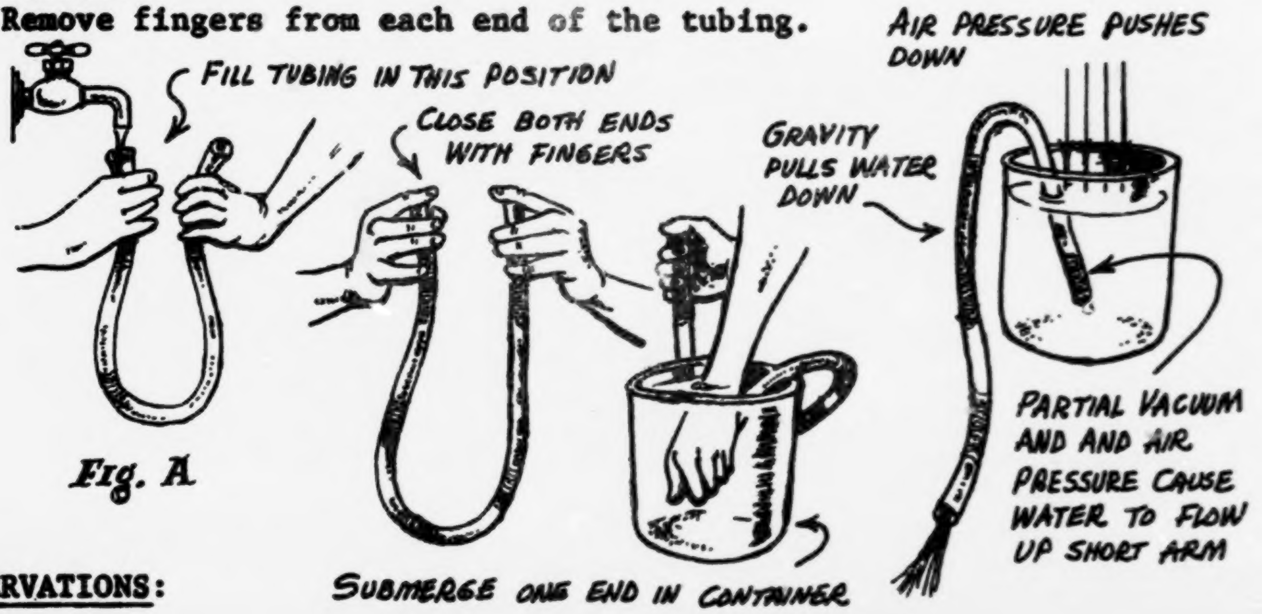

AIR PRESSURE PUSHES DOWN
FILL TUBING IN THIS POSITION
CLOSE BOTH ENDS WITH FINGERS
GRAVITY PULLS WATER DOWN
PARTIAL VACUUM AND AND AIR PRESSURE CAUSE WATER TO FLOW UP SHORT ARM
SUBMERGE ONE END IN CONTAINER

Fig. A

IV. OBSERVATIONS:

A. When fingers were removed from ends of tubing, the water flowed freely from the container, through the tubing and into the catch bucket.

V. CONCLUSION:

A. The siphon operates by gravity and air pressure:
   1. Water falls due to gravity in the long arm, creating a partial vacuum inside the tube.
   2. The air pressure on the surface of the water, in the container being emptied, forces the water up the short arm of the tube.

B. This system can be used to empty dirt, fine sand, or water from an aquarium without disturbing the plants and fish.
C. This system can also be used to transfer liquids from one container to another when no other means is available.

WEATHER

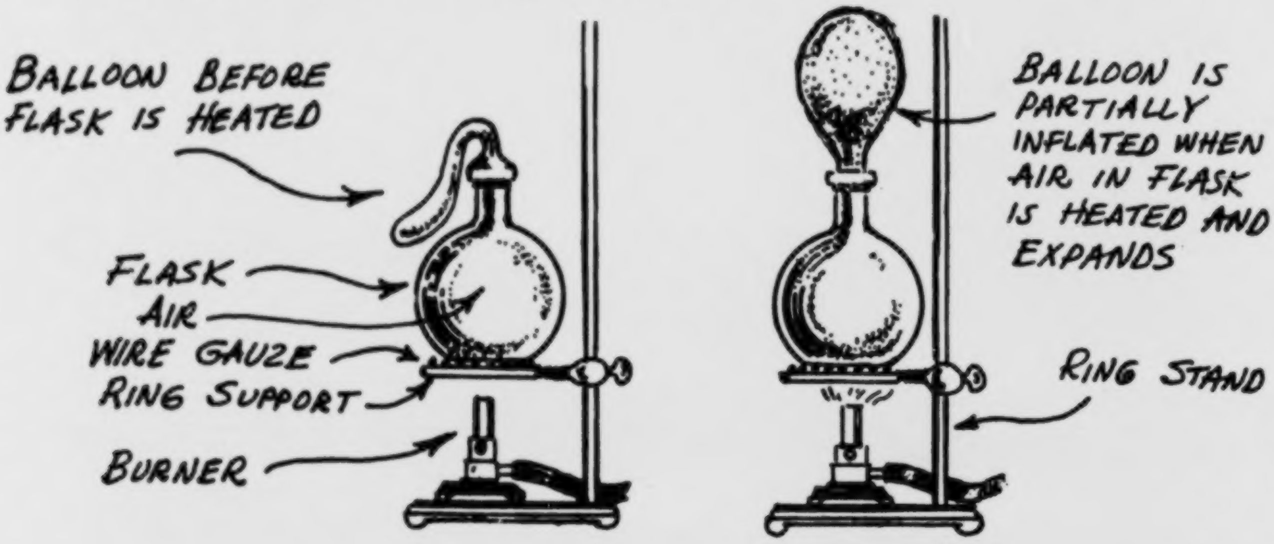
I. **OBJECTIVE:** To show that air expands when heated

II. **MATERIALS:**

- A. Balloon
- B. Flask
- C. Source of heat --- hot plate or burner
- D. Ringstand assembly

III. **PROCEDURE:**

- A. Fit balloon over mouth of flask and heat gently, --- observe balloon
- B. Allow flask to cool and observe balloon


BALLOON BEFORE FLASK IS HEATED
FLASK
AIR
WIRE GAUZE
RING SUPPORT
BURNER
BALLOON IS PARTIALLY INFLATED WHEN AIR IN FLASK IS HEATED AND EXPANDS
RING STAND

IV. **OBSERVATIONS:**

- A. The balloon, which was limp, partly inflated when the flask was heated.
- B. When the flask was allowed to cool, the balloon became limp again.

V. **CONCLUSION:**

- A. The cool air inside the flask expanded when it was heated, inflating the balloon partly.
- B. When cooled, the air contracted, allowing the balloon to become limp again.

AIR EXPANDS WHEN HEATED ---- AIR CONTRACTS WHEN COOLED

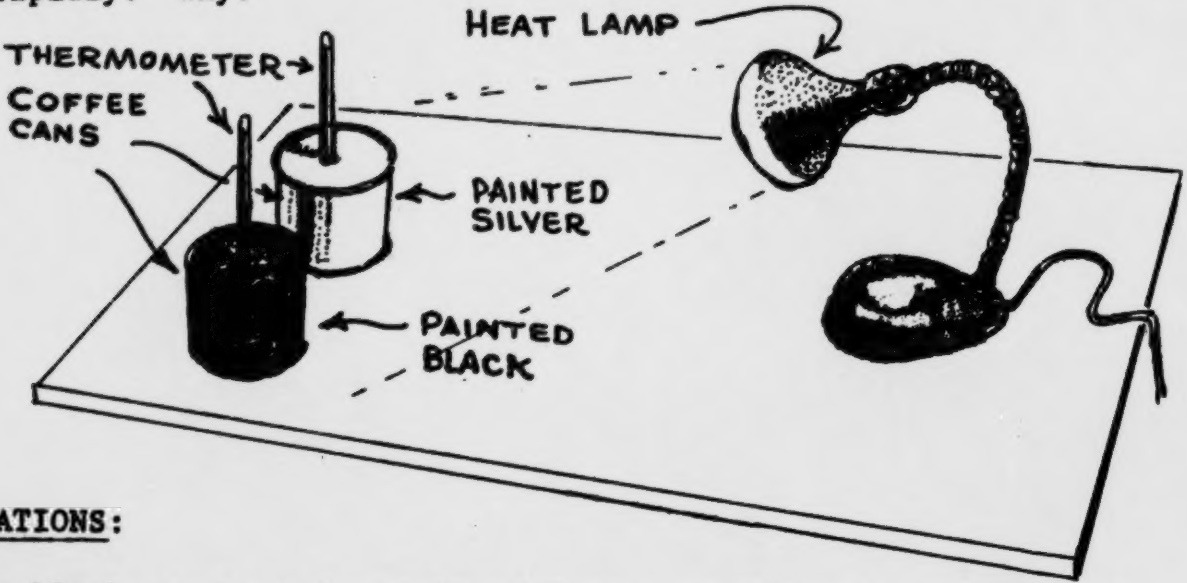
WEATHER

I. **OBJECTIVE:** Dark objects absorb more heat than light or shiny objects.

II. **MATERIALS:**
- A. 2 coffee cans of equal size, with lids.
- B. Aluminum paint and black paint
- C. 2 thermometers
- D. Heat lamp

III. **PROCEDURE:**

- A. Paint one of the cans and one of the lids black.
- B. Paint the other can and lid aluminum.
- C. Drill hole in each lid so that thermometer fits snugly.
- D. If necessary, fit rubber band around thermometers to hold in desired position.
- E. Turn heat lamp on so that it is exposing each can equally, -- record temperatures every few minutes. Which can heated most rapidly? Why?



IV. **OBSERVATIONS:**

- A. The black can heated considerably more rapidly than the aluminum can.

V. **CONCLUSION:**

- A. The black can absorbed more heat than the aluminum can.
- B. The aluminum can reflected much of the radiant energy of the heat lamp.
- C. Dark clothes and objects absorb more heat than light clothes and objects.
- D. The earth is heated unevenly by the sun due to the various colors of grass, soils, pavements, buildings, sands, etc., including water.

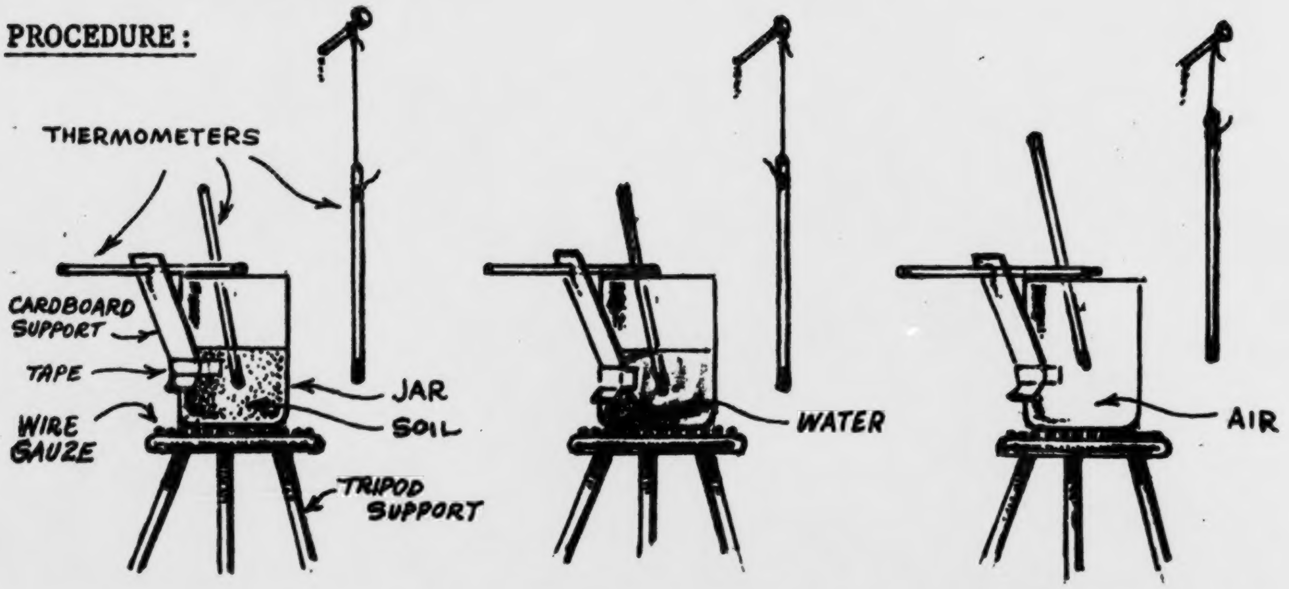
WEATHER

I. OBJECTIVE: To show that the air is heated by contact with the land and water.

II. MATERIALS:

- A. Three, half gallon or larger jars --- battery jars if available
- B. Nine thermometers
- C. Soil from a shady area
- D. Cold water

III. PROCEDURE:



- A. Fill one jar half full of soil from a shady area --- record temperature.
- B. Fill one jar half full of cold water --- record temperature.
- C. Leave third jar empty of any material except the air inside.
- D. Place the three jars on a support as indicated in a sunny area.
- E. Using masking tape, string, or rubber bands, suspend a thermometer in the soil, water and the empty jar at the same depth.
- F. Fasten another thermometer at the center of the opening of each jar.
- G. Fasten still another thermometer six inches to the side of each jar, making certain that each thermometer is at the same level.
- H. At fifteen minute intervals, record the temperatures as indicated in the chart on the following page.
- I. While waiting for temperature readings, record the temperature of the air in various spots: near the floor or groung; in sunny spots; in shady spots; at different levels above the ground, etc.
- J. When "I" is completed, place the three jars in a shady spot and record temperatures every fifteen minutes as in the chart following.

WEATHER

	SOIL			WATER			EMPTY JAR		
	Soil Temp.	Side Temp	Temp at Opening	Water Temp	Side Temp	Temp at Opening	Inside Temp	Side Temp	Temp at Opening
Start									
15 min.									
30 min.									
45 min.									
60 min.									
75 min.									
90 min.									

IV. OBSERVATIONS:

A. Where was the temperature rise the greatest?
B. Where was the temperature rise the least?
C. Does this explain how the atmosphere is heated?
D. Which cooled most rapidly, soil water or the empty jar?

V. CONCLUSION:

A. Radiant energy from the sun heats the land and water, convection currents from the land and water then heat the air.

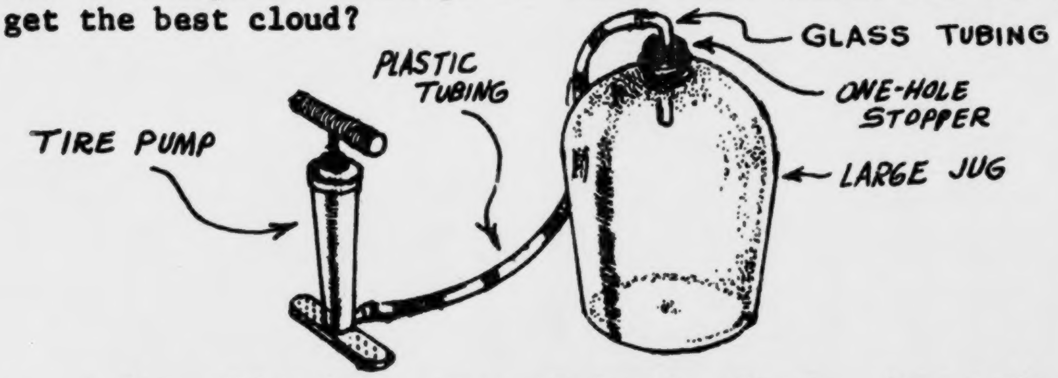
B. Land is heated more quickly than water, but also cools more quickly than water, thus evening breezes are from the bodies of land to the bodies of water; daytime breezes are towards the land.

WEATHER

I. **OBJECTIVE**: Making a cloud in a jug and explaining what causes this to happen.

II. **MATERIALS**:
- A. Large glass jug -- the larger the better
- B. One-hole rubber stopper to fit jug
- C. Short piece glass tubing to fit rubber stopper
- D. Tire pump and rubber tubing
- E. Spoonful of water
- F. Punk stick

III. PROCEDURE:
- A. Fit one-hole stopper with glass tubing
- B. Connect pump to tubing with rubber tube
- C. Pump air into jug until stopper blows out ---stand slightly to the side of jug while pumping pressure
- D. OBSERVE closely what happens inside the jug as the stopper blows out.
- E. Add a spoonful of water and repeat A through D. Do you get a better cloud?
- F. Insert a smoking punk stick in the jug for about a minute and then repeat A through D. Under what conditions did you get the best cloud?



IV. **OBSERVATIONS**:
- A. A fine white haze appeared inside the jug when A through D completed.
- B. A denser haze appeared after moisture was added and experiment repeated.
- C. A very dense haze (cloud) appeared after smoke and moisture added and experiment repeated.

V. CONCLUSION:
- A. When air in the jug expanded, it suddenly cooled and released its moisture in the form of a cloud --- warm air can hold more moisture than cool air.
- B. When the moisture was added, the cloud became denser since moisture is essential for the formation of clouds.
- C. The addition of smoke, which is actually fine particles of carbon, acts as the nucleus for the moisture to condense upon.

WEATHER

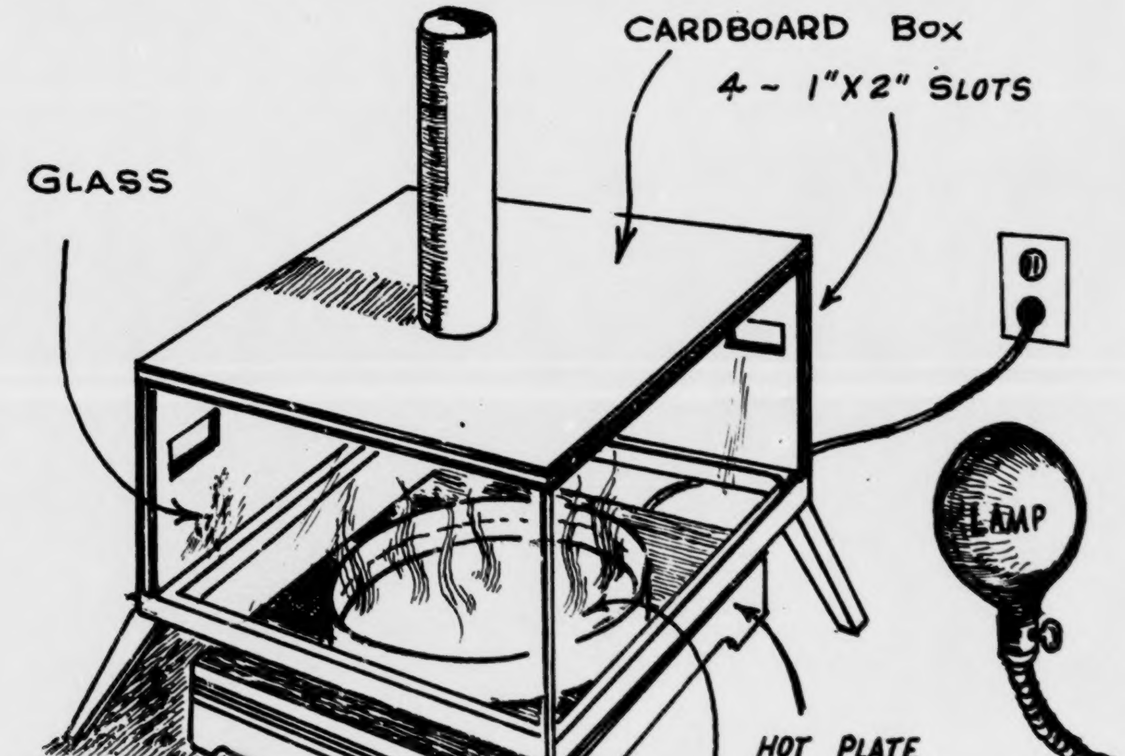
I. OBJECTIVE: To show how a tornado is formed and the direction of winds in a tornado.

II. MATERIALS:

A. Cardboard box about 15" X 15" X 15"
B. Two pieces of glass, same dimensions as two sides of the box
C. Cardboard tube, six inches in diameter and four feet long
D. One electric hot plate, a pan and water
E. Tape
F. Legs or other support for box
G. Black paint
H. Flexible gooseneck type lamp and 100 watt bulb

III. PROCEDURE:

A. Assemble and set up apparatus as illustrated
B. The tube can be assembled from cardboard or 6" stovepipe can be used
C. Paint inside of the two remaining walls black
D. Heat the pan of water below the box as illustrated
E. Shine the light through one glass side and look through the other
F. If a cloud is not visible in the box, blow some chalk dust or smoke in through the slots



IV. OBSERVATIONS:

A. A cloud formed inside the box.

B. The air currents moved in a counter clockwise direction towards the center and upwards through the tube.

V. CONCLUSION:

A. Tornadoes are funnel-shaped clouds with high wind velocities towards the center at up to 500 mph, and up-drafts in excess of 100 mph.

B. Convection currents cause warm, moist air to become superheated and rise rapidly. As the warm air meets cool air currents, whirling winds are set in motion.

C. Air pressure at the center of a tornado is very low.

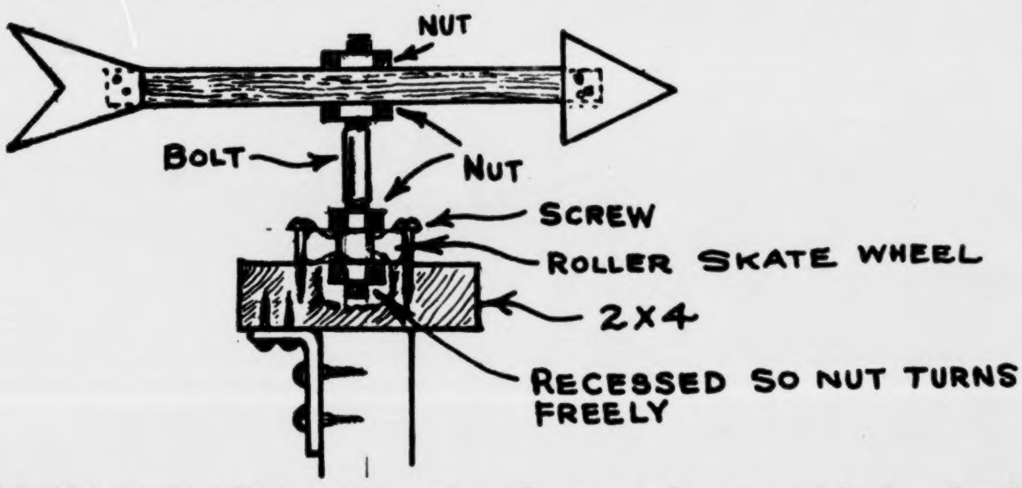
WEATHER

I. OBJECTIVE: To make a working wind vane and to explain how it works.

II. MATERIALS:
- A. Wheel from an old roller skate
- B. One 2" x 4" - 12" long
- C. 3/8 inch bolt, 6 inches long, with four nuts for same.
- D. One 1" x 2" - 18" long
- E. Four pieces of aluminum or other thin metal
- F. Three screws and washers

III. PROCEDURE:

- A. Drill hole in center of 2 x 4 so that nut on bottom of wheel can turn freely.
- B. Cut two pieces of the metal into a tail fin and attach as illustrated to 1 x 2.
- C. Cut 2 pieces of metal into point for nose and attach as illustrated.
- D. Find the point on the arrow where it balances and drill 3/8" hole.
- E. Complete assembly and paint.
- F. Lubricate wheel prior to installing and then about every 6 months.
- G. Install on a firm support that is free of obstruction such as trees, buildings, etc.
- H. Using a compass, install marker for the cardinal points, ---N-E-S-W.



IV. OBSERVATIONS:

- A. This is a working weather vane and, if properly assembled, should function satisfactory for a long period of time.

V. CONCLUSION:

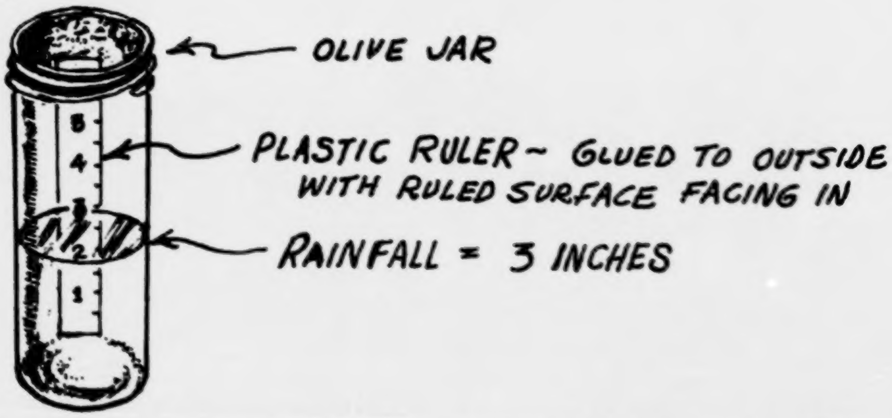
- A. A wind vane always points into the wind, that is, the direction the wind is coming from. If the vane points to the east, then the wind is blowing from the east and towards the west.
- B. The larger rear fin helps or causes the arrow to point into the wind.
- C. A weather vane must be able to swing freely if it is to function correctly, so be certain that it is well lubricated at all times.

WEATHER

I. OBJECTIVE: To make an inexpensive rain gauge and explain how it works.

II. MATERIALS:
- A. Olive jar, or other tall narrow jar
- B. Plastic ruler
- C. Waterproof glue or tape

III. PROCEDURE:
- A. Attach plastic rule to jar with waterproof tape or glue as illustrated, making certain that one inch end is down and even with the bottom of jar. Also, make certain that scale on rule is facing in, so you will look through the water and the jar for the reading.
- B. Place rain gauge out of doors in an open area.
- C. As soon as possible after each rainfall, hold gauge vertical and take reading, and record along with other weather information.


OLIVE JAR
PLASTIC RULER ~ GLUED TO OUTSIDE WITH RULED SURFACE FACING IN
RAINFALL = 3 INCHES
5
4
3
2
1

IV. OBSERVATIONS:

- A. This is an inexpensive way to make a fairly accurate rain gauge. The accuracy of the measurement depends solely upon the person taking the reading.

V. CONCLUSION:

- A. No calibrations are necessary with this type of rain gauge -- you get a direct reading.
- B. Readings should be made as soon as possible after each rainfall so that evaporation does not affect the accuracy of the measurement.
- C. Be sure to empty the rain gauge after each reading, and after each rainfall.

NOTE:
- A. Some companies, such as feed and fertilizer companies give away small rain gauges that are accurate.
- B. A small, accurate rain gauge can be purchased in most hardware stores for less than one dollar.

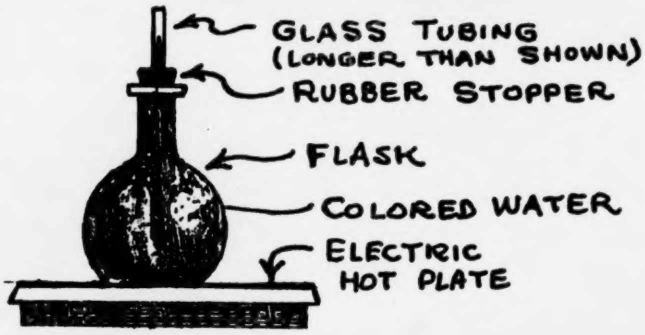
HOWEVER: Our homemade rain gauge is just as accurate as any of the above, plus we have the pleasure of knowing that we made it ourself.

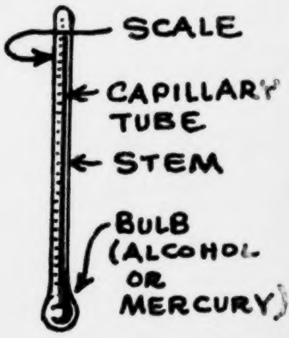
WEATHER

I. **OBJECTIVE**: To explain how a liquid thermometer works.

II. **MATERIALS**:
- A. Working thermometer
- B. Broken thermometer
- C. Flask
- D. Rubber stopper fitted with glass tubing
- E. Water
- F. Food coloring
- G. Source of heat

III. **PROCEDURE**:
- A. Set up apparatus as illustrated
- B. Mix food coloring with water
- C. Heat gently and observe - heat of hands should be sufficient
- D. Place in pan of cold water and observe.
- E. Closely examine the stem of the broken thermometer.





IV. **OBSERVATIONS**:

- A. The water was more visible after the food coloring was mixed.
- B. When heated gently, the water rose in the glass tubing.
- C. When cooled, the level of the colored water dropped.
- D. The opening in the stem of the broken thermometer is finer than a hair.

V. **CONCLUSION**:

- A. The colored water expanded as it was heated and thus rose in the glass tubing. When cooled, it contracted and the level dropped.
- B. Most household thermometers contain alcohol which has been colored.
- C. Colored alcohol, like the colored water is easier to see.
- D. An alcohol thermometer is less expensive than a mercury thermometer.
- E. A mercury thermometer is more accurate than an alcohol thermometer.
- F. The fine opening in the tube of a thermometer is actually a thick-walled capillary, the air having been expelled by heating the mercury in the bulb, allowing it to expand, fill the tube, and the tube is then sealed of
- G. Because the air has been expelled, the mercury can expand and contract freely as the temperature changes.

VI. DISCUSSION:
- A. Temperature: The degree of hotness or coldness of an object in degrees, Fahrenheit or centigrade. A measure of thermal energy.
- B. Heat: A form of energy produced by the vibration of molecules.
- C. Cold: A temperature much lower than the human body.
- D. Absolute Zero: (-273° C. or -459.6° F.) the lowest possible temperature: All molecular action has stopped -- all possible thermal energy has been given up.

WEATHER

BAROMETER:

GENERAL INFORMATION:

1. Invented by Torricelli in 1643 --- (the mercury barometer)

2. The mercury barometer is more accurate, but also more expensive and more fragile than the aneroid barometer.

3. The aneroid barometer is more portable, and calibrated to read the same as mercury barometer --- in terms of the height of a column of mercury that the atmospheric pressure will support.

4. The altimeter -- (an instrument for measuring distance above sea level) is constructed the same as an aneroid barometer, but has a scale indicating feet above sea level rather than inches of mercury.

5. The specific gravity of mercury is 13.546. This means an equal volume of mercury is 13.546 times heavier than the same volume of water.

6. A barometer could just as well be constructed of tubing and water.
   It would have to be about 36 feet high.
   The water would freeze in cold climates.
   The water would evaporate from the reservoir at the bottom.

7. The barometer is but one of the many different instruments used in forecasting the weather. It indicates small changes in air pressure in terms of the height of the column of mercury that can be supported.

8. RISING BAROMETER indicates fair weather
   FALLING BAROMETER indicates stormy weather
   STEADY BAROMETER indicates no changes in weather

WEATHER

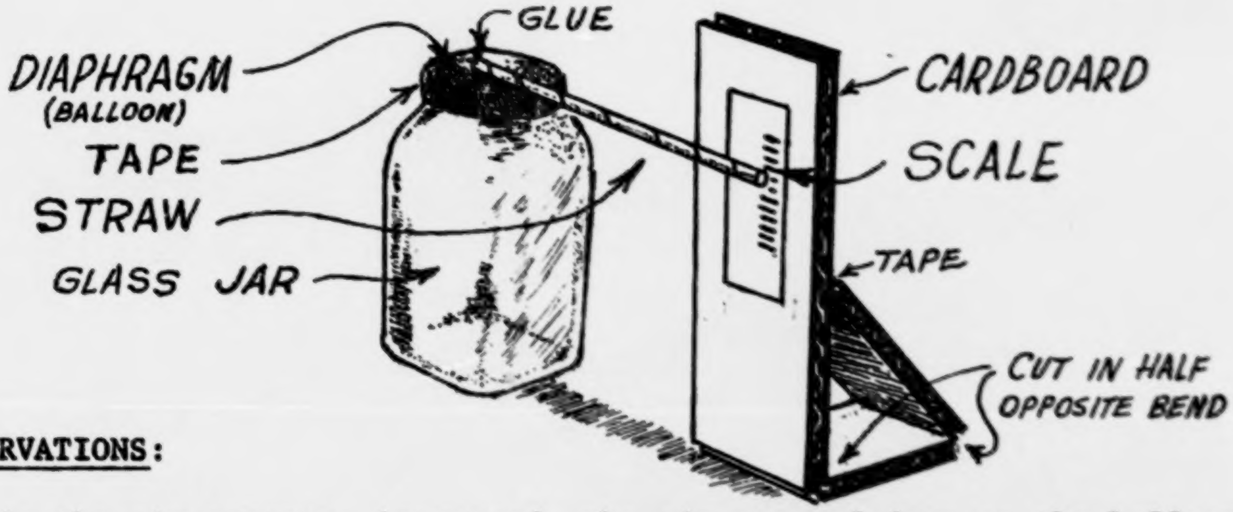
I. **OBJECTIVE**: To make an aneroid barometer and explain how it works.

II. **MATERIALS**:

- A. Glass jar
- B. Large balloon
- C. Adhesive or other tape
- D. Soda straw (plastic, if available
- E. Glue
- F. Sheet of cardboard

III. **PROCEDURE**:

- A. Assemble apparatus as illustrated, making certain that the balloon is stretched tightly across the mouth of the jar, and taped tight as indicated.
- B. Assemble cardboard, as shown,and draw scale -- space markings evenly and number.
- C. Record readings of barometer over a period of a week or longer.



IV: **OBSERVATIONS**:

- A. As the air pressure increased, the air pressed down on the balloon, causing the straw (the pointer) to point to a higher reading on the scale.
- B. As the air pressure decreased, the air in the jar expanded slightly, allowing the balloon to bulge upwards and causing the pointer (the straw) to point to a lower position on the scale.

V. **CONCLUSION**:

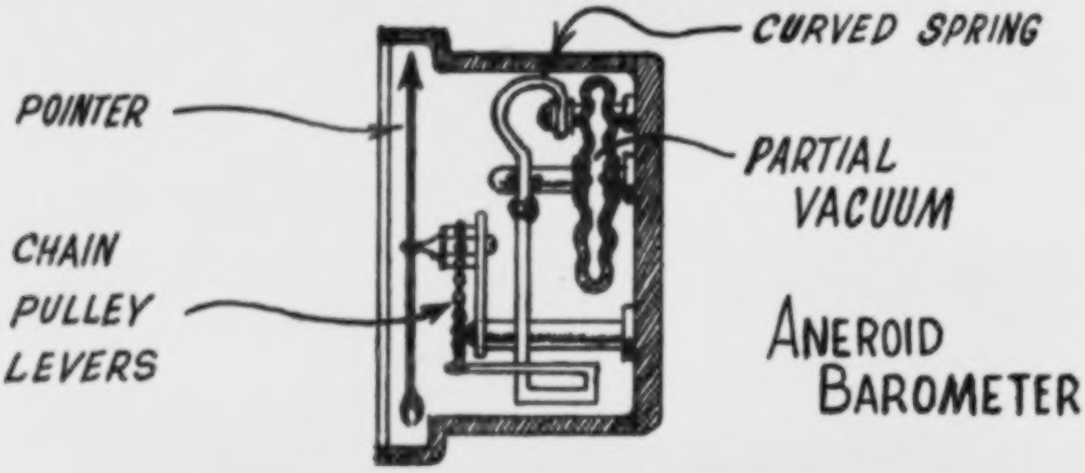
- A. The aneroid barometer operates with the change in atmospheric pressure.
- B. As the pressure increases, the air is actually heavier, causing the diaphragm (the balloon) to bulge down or inward.
- C. As the diaphragm moves up and down, the free end of the straw moves in the opposite direction, the straw amplifying these movements.
- D. Keep the barometer away from extreme heat or cold --- heat causes the air in the jar to expand and cold will cause the air in the jar to contract, and a false reading will result.

WEATHER

I. **OBJECTIVE:** To dissect and explain how an aneroid barometer works.

II. **MATERIALS:**
- A. Old, non-working aneroid barometer.
- B. Large drawing of internal parts of aneroid barometer.

III. **PROCEDURE:**
- A. Point out the main parts of the barometer on the drawing. At the same time, show the identical part from the barometer.
- B. Explain the operation and function of each part.



IV. **OBSERVATIONS:**

- A. The "heart" or main part of an aneroid barometer is a hollow metal disc from which the air has been partially removed. (evacuated)
- B. This thin metal disc is sensitive to very small changes in air pressure.
- C. It is connected by means of levers, chains and gears to the pointer.
- D. As the air gets lighter, it weighs less and the pressure on the disc is less, --- allowing the disc to expand and move the needle to a lower position on the scale.
- E. The scale on the aneroid barometer is calibrated (adjusted and marked) to read the same as a mercury barometer --- inches of mercury. IT DOES NOT INDICATE AIR PRESSURE IN POUNDS PER SQUARE INCH.

V. **CONCLUSION:**

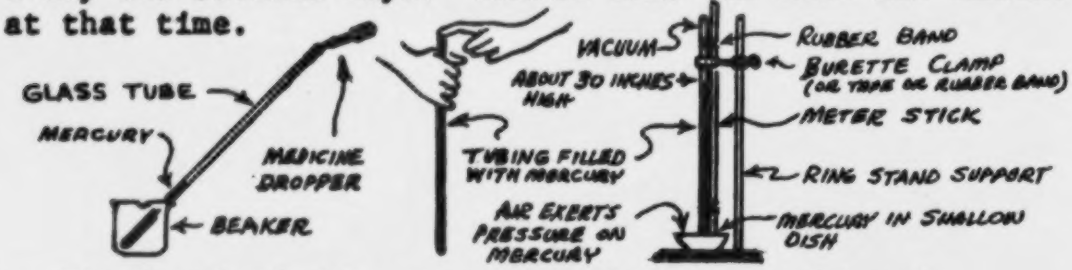
- A. Heavy air weighs more, the pressure increases causing the metal disc to squeeze together and making the needle point higher on the scale.
- B. Lighter air weighs less, the pressure decreases causing the air inside to expand and allow the needle to point lower on the scale.
- C. RISING BAROMETER --- indicates fair weather
  FALLING BAROMETER --- indicates stormy weather
  STEADY BAROMETER ---- indicates no change in weather.

WEATHER

I. **OBJECTIVE:** To construct and explain the operation of a mercury barometer.

II. **MATERIALS:**
- A. Glass tube about 36 inches long
- B. 2 Or 3 pounds of mercury - possibly 5 pounds
- C. Shallow dish
- D. Ring stand support
- E. Meter stick or yard stick, masking tape and rubber bands
- F. Bunsen or other gas burner
- G. Medicine dropper pipette
- H. Large beaker, battery jar, or other container.

III. **PROCEDURE:**
- A. Heat one end of glass barometer tubing and seal closed - allow to cool slowly.
- B. When completely cool, fill tubing with mercury, making certain there are no air bubbles in the tube. To best accomplish filling, tilt tubing and fill with medicine dropper. A thin insulated copper wire inserted in tube will help in filling.
- C. Holding index finger over open end of the tubing, invert and place open end under mercury in shallow dish.
- D. Attach yard stick or meter stick to tubing with rubber bands, adjusting bottom end of stick to the level of mercury in shallow dish.
- E. Now attach yard stick and tubing to ring stand support with tape or rubber bands.
- F. Observe level (height) of mercury in tube several times a day for several days. Record this and also the weather at that time.


GLASS TUBE
MERCURY
BEAKER
MEDICINE DROPPER
TUBING FILLED WITH MERCURY
VACUUM
ABOUT 30 INCHES HIGH
AIR EXERTS PRESSURE ON MERCURY
RUBBER BAND
BURETTE CLAMP (OR TAPE OR RUBBER BAND)
METER STICK
RING STAND SUPPORT
MERCURY IN SHALLOW DISH

IV. **OBSERVATIONS:**
- A. The level of the mercury in the glass tubing is _________ inches.
- B. A mercury barometer is expensive, fragile, and not too portable.

V. **CONCLUSION:** A mercury barometer does not measure air pressure -- it measures the height of a column of mercury the air pressure will support. As small changes in the atmospheric pressure occur, the height of the column of mercury rises or falls as the pressure increases and decreases, thus small changes in atmospheric pressure are detected and indicated by changes in the height of the column of mercury.

RISING BAROMETER = or indicates fair weather. FALLING BAROMETER indicates stormy weather. STEADY BAROMETER indicates no change in weather.

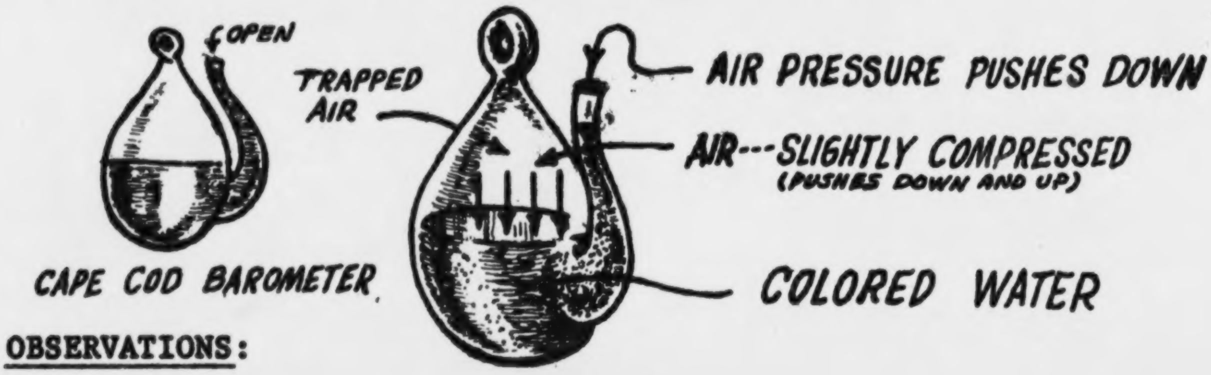
WEATHER

I. **OBJECTIVE:** What is a Cape Cod barometer and how does it work?

II. **MATERIALS:**
- A. Cape Cod barometer
- B. Water
- C. Food coloring

III. **PROCEDURE:**

- A. If the barometer is not already filled with water, add coloring to a supply of water and proceed to fill, being careful not to fill more than about half full. Medicine dropper may be necessary for filling.
- B. Make a scale reading from one to ten, attach to neck of barometer.
- C. Observe and record readings on barometer for a week or longer.
- D. Compare movement of colored water in the neck of the Cape Cod barometer to the movement of the needle on an aneroid barometer or the column of mercury in a mercury barometer.



IV. **OBSERVATIONS:**

- A. Food coloring makes water more visible.
- B. As the air pressure increases, the colored water in the neck goes down. At the same time the needle on the aneroid barometer and the mercury in the mercury barometer, went up.

V. **CONCLUSION:**

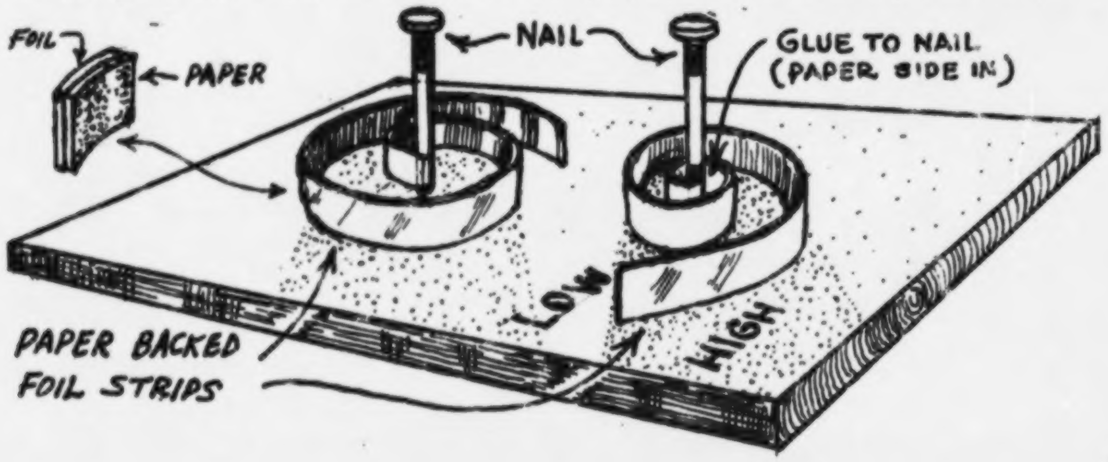
- A. The water in the neck decreases (goes down) as the air pressure increases and pushes harder against the exposed area in the neck.
- B. As the water in the neck is pushed on by increased air pressure, the the air in the space above the water inside the barometer is slightly compressed.
- C. As the air pressure decreases, the water in the neck rises due to the fact that it is not being pushed on as much from the outside, allowing the slightly compressed air on the inside force it up and into the neck a little further.

WEATHER

I. **OBJECTIVE**: Making and explaining how a hygrometer made from paper-backed aluminum foil works.

II. **MATERIALS**:
- A. Plywood or other wood, 18 inches x 18 inches
- B. Two nails
- C. Glue
- D. Paper-backed foil from chewing gum or soap
- E. Medicine dropper
- F. Water

III. **PROCEDURE**:
- A. Cut paper-backed foil into half inch wide strips.
- B. Glue one end of each strip to a nail -- (paper side in) - nails spaced several inches.
- C. Roll each strip tightly around the nail to which attached, with foil out.
- D. Wet each coil of paper with water from medicine dropper.
- E. Mark position of loose end of paper when moist, and when dry.



IV. **OBSERVATIONS**:

- A. When moistened with a few drops of water, the paper uncoiled.
- B. As the paper dried out, it coiled up again.

V. **CONCLUSION**:

- A. As the paper absorbes the moisture, it expands causing the metal foil to bend and uncoil.
- B. As the paper dries out, it shrinks (contracts) bending the foil in the opposite direction and coils up again.
- C. Many hygrometers are constructed in this manner, having a needle or pointer attached to the paper-backed foil so that it can move freely over a scale.
- D. The scale of this type of hygrometer is read directly, -- you do not have to refer to tables as in the wet and dry bulb type.

WEATHER

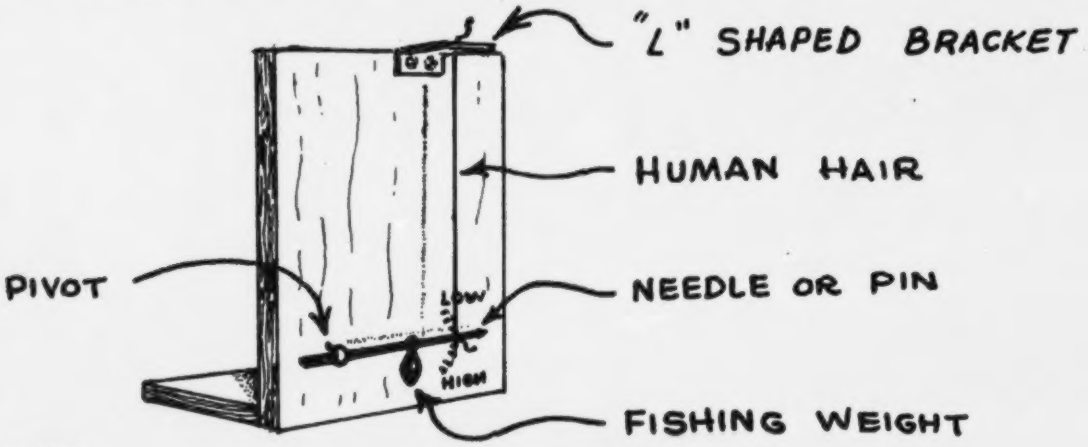
I. **OBJECTIVE:** To make a hair-type hygrometer.

II. **MATERIALS:**

A. Long strand of human hair.
B. Carbon tetrachloride
C. Small fishing sinker
D. 3/4 inch plywood, 6 inches x 18 inches
E. Straight pin or needle
F. "L" shaped bracket

III. **PROCEDURE:**

A. Soak hair in carbon tetrachloride for 24 hours to remove natural oils.
B. Assemble apparatus as illustrated.
C. Number the scale, starting with the top or "low" reading and going down the scale.
D. Record hygrometer reading for several days and compare reading with correct weather conditions.



IV. **OBSERVATIONS:**

A. As the water vapor in the air increases, the hair stretches slightly and allows the pointer to move.
B. As the water vapor in the air decreases, the hair shrinks slightly and causes the pointer to move in the opposite direction.

V. **CONCLUSION:**

A. A hygrometer measures relative humidity.
B. Relative humidity is the amount of water vapor the air is holding in relation to what it could hold at that particular time and temperature.

WEATHER

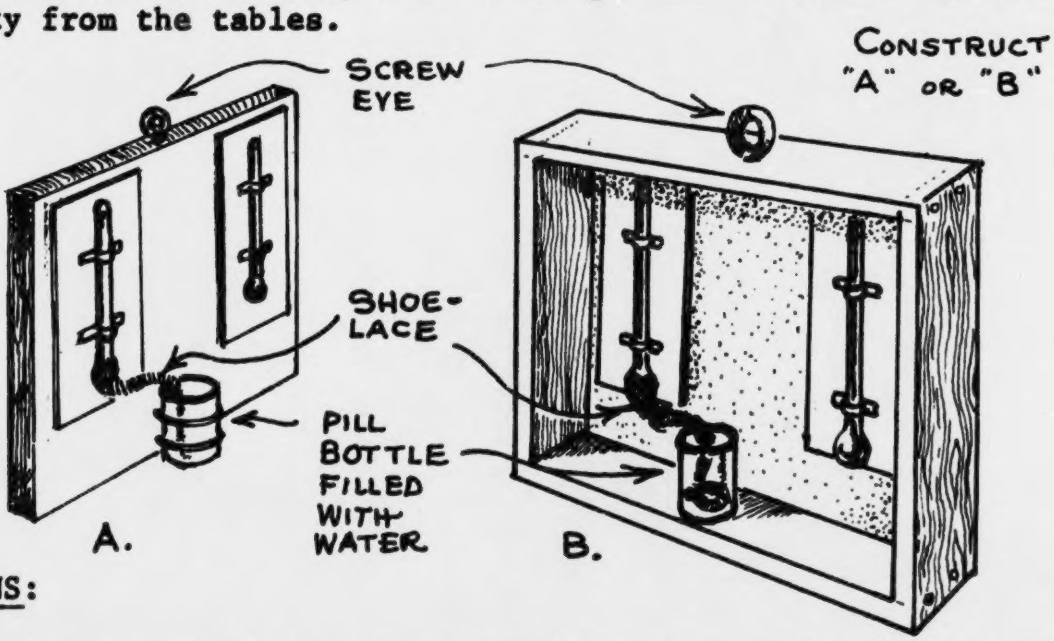
I. **OBJECTIVE**: To construct a hygrometer and explain how it works.

II. **MATERIALS**:

- A. Two identical thermometers
- B. 3/4 inch x 4-1/2 inches x 8 inches - - plywood or pine board
- C. Length of white shoe lace
- D. Plastic or glass pill bottle (clear)
- E. Glue
- F. Screw eye
- G. Relative humidity tables

III. **PROCEDURE**:

- A. Assemble as illustrated
- B. Slip shoe lace over bulb of one thermometer and place other end in pill bottle.
- C. Fill pill bottle with water -- hang hygrometer on the wall.
- D. After hygrometer has been hanging on the wall for several minutes, check both the wet and dry bulb readings and determine relative humidity from the tables.



IV. **OBSERVATIONS**:

- A. After hanging on the wall for several minutes, the wet bulb thermometer showed a lower temperature than the dry bulb.
- B. Relative humidity could easily be obtained from the tables once the wet and dry bulb readings were known.

V. **CONCLUSION**:

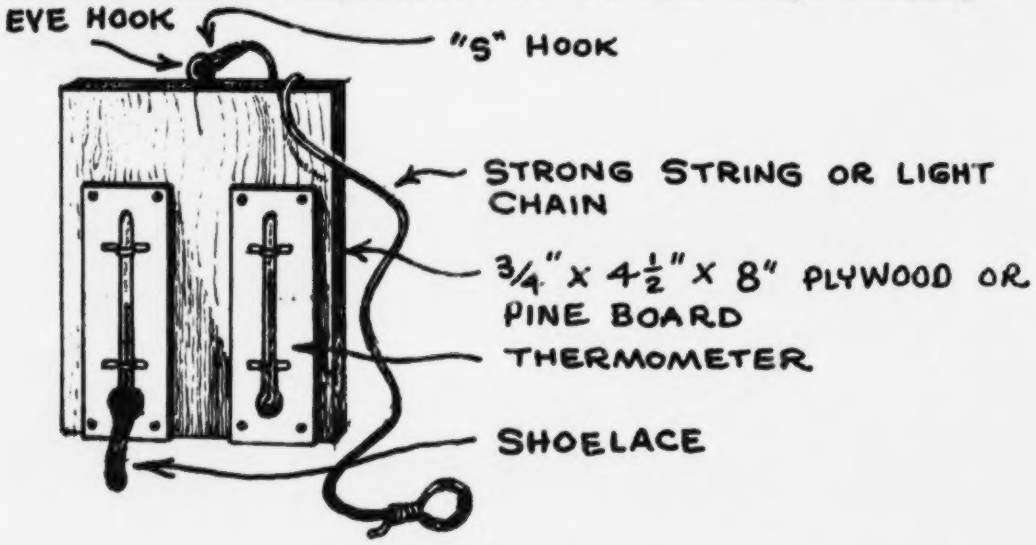
- A. The wet bulb thermometer showed a lower reading because evaporation is a cooling process.
- B. Remember -- this gives the relative humidity for the room or area where the hygrometer is located. NOT FOR THE OUT OF DOORS.

WEATHER

I. OBJECTIVE: To make a sling psychrometer and explain how it works.

II. MATERIAL:
- A. Two thermometers
- B. Eye hook
- C. 3/4 inch x 4-1/2 inchs x 8 inches plywood or pine board
- D. "S" hook
- E. About 24" light weight chain or strong cord (nylon)
- F. Length of white shoe lace

III. PROCEDURE:
- A. Assemble as illustrated.
- B. Slip shoe lace over bulb of one thermometer and moisten
- C. Swing the psychrometer in a circular motion, checking and recording the temperature of each thermometer every 15-20 seconds.
- D. Continue until temperature on wet bulb stops falling.


EYE HOOK
"S" HOOK
STRONG STRING OR LIGHT CHAIN
3/4" x 4 1/2" x 8" PLYWOOD OR PINE BOARD
THERMOMETER
SHOELACE

IV. OBSERVATIONS:
- A. The wet bulb always read less than the dry bulb.
- B. The wet bulb temperature continued to drop while the psychrometer was being spun about, until it reached a certain point, then it stopped falling.

V. CONCLUSION:
- A. The spinning causes wind which hastens evaporation of the water on the shoe lace.
- B. Evaporation is a cooling process.
- C. The more moisture in the air, the less the evaporation and the less the temperature drops on the wet bulb.
- D. The drier the air, the more rapid the evaporation, the lower the temperature on the wet bulb thermometer.

SOUND

CONTENT:

INTRODUCTION

VOCABULARY

CONCEPT

Parts of the ear and their functions.

To demonstrate that sound originates from vibrating objects.

To demonstrate how sound waves travel.

To show that solids are good conductors of sound.

To show that water conducts sound better than air.

To construct a string telephone and explain how it works.

To demonstrate and explain how a megaphone works.

To show how the knowledge of the speed of sound can be used to determine the distance of lightning.

To demonstrate that sound waves will not form unless matter is present. (Sound cannot travel in a vacuum)

To demonstrate that sound waves will not form unless matter is present. (Sound cannot travel in a vacuum)

To show the difference between frequency (pitch) and amplitude in sound waves.

SOUND

I. INTRODUCTION:

1. What is sound?
   - A. That which is or can be heard - the sensation of hearing - a form of energy.

2. What causes sound?
   - A. A vibrating object.

3. Do all vibrating objects cause sound?
   - A. No. The range of the human ear is between sixteen cycles (vibrations) per second to twenty thousand cycles per second. The average person hears vibrations between 100 to 12,000 cycles per second.

4. What is meant by the term "Hi-Fi?"
   - A. High fidelity, or high quality of reproduction - accuracy and quality of reproduction, especially regarding sound.

5. What determines whether a radio, phonograph, tape recorder, or TV is "Hi-Fi?"
   - A. Unfortunately, there are not set standards. Phonographs and tape recorders ranging in price from just a few dollars up to several thousand dollars are quite often marked as being "Hi-Fi." Probably the determining factor in the end is whether or not the purchaser and or the listener feels that the sound produced by the particular piece of equipment is pleasing and does represent a high quality of reproduction. If the set reproduces all sounds within the range of the particular listener, then it might well be classed as high fidelity for that particular person. However, the same set might well be below the range of another person whose ears are more sensitive to the higher and lower frequencies. Another factor that must not be overlooked is quality of the tone, as well as the frequency being reproduced.

6. What is meant by stereophonic?
   - A. A term used to denote a three dimensional reproduction of sound, such as in motion pictures, recordings, phonographs and radios. Two or more channels are used to carry and reproduce the sounds from the directions in which they were originally picked up by two or more microphones.

7. What makes it possible for us to hear the various sounds?
   - A. As an object vibrates, it sets the air around it in motion and causes the molecules to vibrate and move outward in all directions. These waves or motions of the air are called sound waves. Our eardrum, which is a thin membrane, in turn vibrates at the same rate as the air allowing us to interpret these motions of air as sound.

SOUND

8. What is the main purpose of our ear?
   A. It is our organ of hearing, however, it does contain the semicircular canals which control our equilibrium. (balance)

9. Is air the best conductor of sound?
   A. No. Air is actually a poor conductor of sound, but it is the most common conductor so far as the human ear is concerned. Water conducts sound about four times faster than air and steel conducts sounds about fifteen times faster.

10. What is the speed of sound?
    A. Experiments show that the speed of sound is 1,087 feet per second in dry air, 0° Centigrade at sea level. The speed increases slightly as the temperature rises. We usually say that sound travels at 1,100 feet per second (about 750 miles per hour) The speed of sound is referred to as Mach 1 by space travelers. Mach 2 would be twice the speed of sound.

11. What does the term supersonic mean?
    A. It has a two-fold meaning:

       1. Vibrations or frequencies greater or higher than those audible to the human ear. (Above about 20,000 per second)
       2. Designating of a speed greater than that of sound or greater than 1,087 feet per second. (About 750 miles per hour)

12. What does the term "sound barrier" mean?
    A. The sound barrier is the pile-up of air molecules produced when an aircraft or missile approaches the speed of sound.

13. What is involved in "breaking" the sound barrier?
    A. Breaking the sound barrier requires exceeding the speed of sound and passing through the "pile-up" of air molecules. Passing through this barrier requires a great deal of energy; it is like going through a solid wall. The design of airplanes has been changed to reduce the shock when passing through this barrier. Prior to the change of design, airplanes literally flew apart due to the vibrations caused by shock waves that resulted when an aircraft exceeded 750 miles per hour.

14. What does amplitude mean?
    A. It refers to the loudness (intensity) of sound. It is determined by the height of the sound waves, which in turn are determined by the amount of the vibration of matter.

SOUND

15. How is amplitude measured?

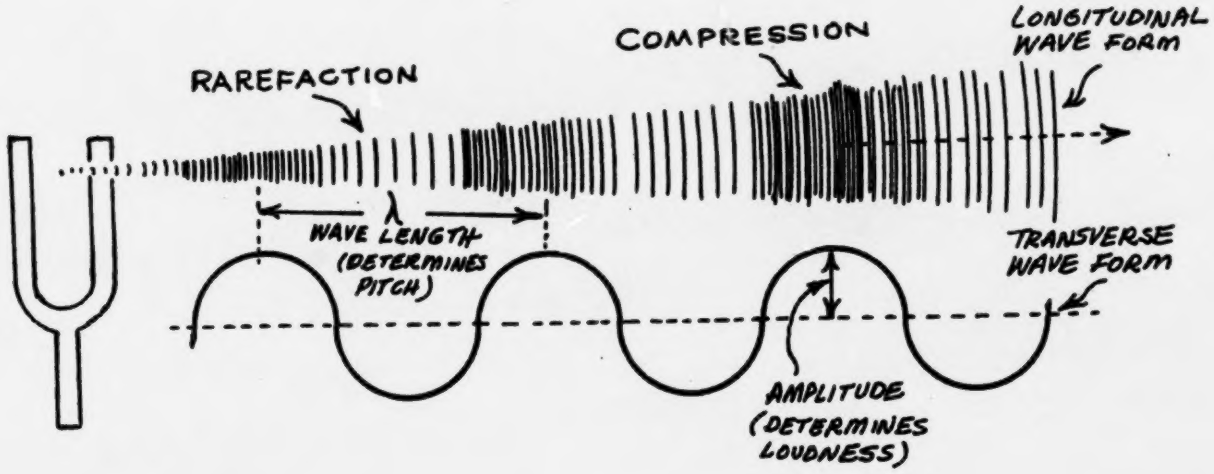
A. It is measured in units called decibels by means of electronic devices.

EXAMPLES:

1.	Whisper	20 decibels
2.	Ordinary conversation, 3 ft.	65 decibels
3.	Noisiest spot at Niagara Falls	95 decibels
4.	Airplane engine, 1,600 R.P.M.	123 decibels
5.	Limit of endurance, human ear	130 decibels
6.	Loudest possible pure tone	190 decibels
7.	12 inch cannon	225 decibels

16. What is meant by frequency?

A. Frequency is the number of complete vibrations of a wave that pass a given point in one second.
IN SOUND, it is the number of compressions and rarefactions per second.


COMPRESSION
LONGITUDINAL WAVE FORM
RAREFACTION
λ
WAVE LENGTH (DETERMINES PITCH)
TRANSVERSE WAVE FORM
AMPLITUDE (DETERMINES LOUDNESS)

17. What is meant by pitch?

A. Pitch is the quality of tone or sound and is determined by the frequency of the sound waves reaching the ear; the greater the frequency, the higher the pitch.

18. What is music?

A. Music is an orderly arrangement of sounds that are pleasing to the ear. These are so arranged as to include rhythm, harmony, melody and tone quality.

19. What is a noise?

A. Noise is any disorganized sound that is not pleasing to the ear. It can be loud, unmusical, or disagreeable in anyway.

SOUND

20. What are sound waves?

    A. See # 7 and # 16.
    Sound waves are motions of the air, a series of compressions and rarefactions, that result from vibrating matter. The energy of a vibrating object is transmitted to the air. These sound waves travel outward in all directions from the vibrating object.

21. What is an echo and what causes it?

    A. An echo is simply a reflected sound wave. Echoes can be formed when you shout towards large buildings, hills, or cliffs. The sound waves created by your voice are reflected and return to you as echoes. The human ear is capable of detecting sounds that occur at least one tenth of a second apart. Because of this, echoes can be formed in rooms that are 55 feet long or longer. The distance that the sound waves would travel in a 55 foot room would be 110 feet, or one tenth of the 1,100 feet that sound travels in one second.

22. What is meant by the term "acoustics?"

    A. Acoustics are the qualities of a room such as a theatre, auditorium, etc. to conduct or transmit sound. The quality of how clearly sounds can be heard in said room. The science of sound.

23. If sound only travels at a speed of 1,100 feet per second, how can we talk from coast to coast in the United States, or to distant points in the world with no apparent time-lapse?

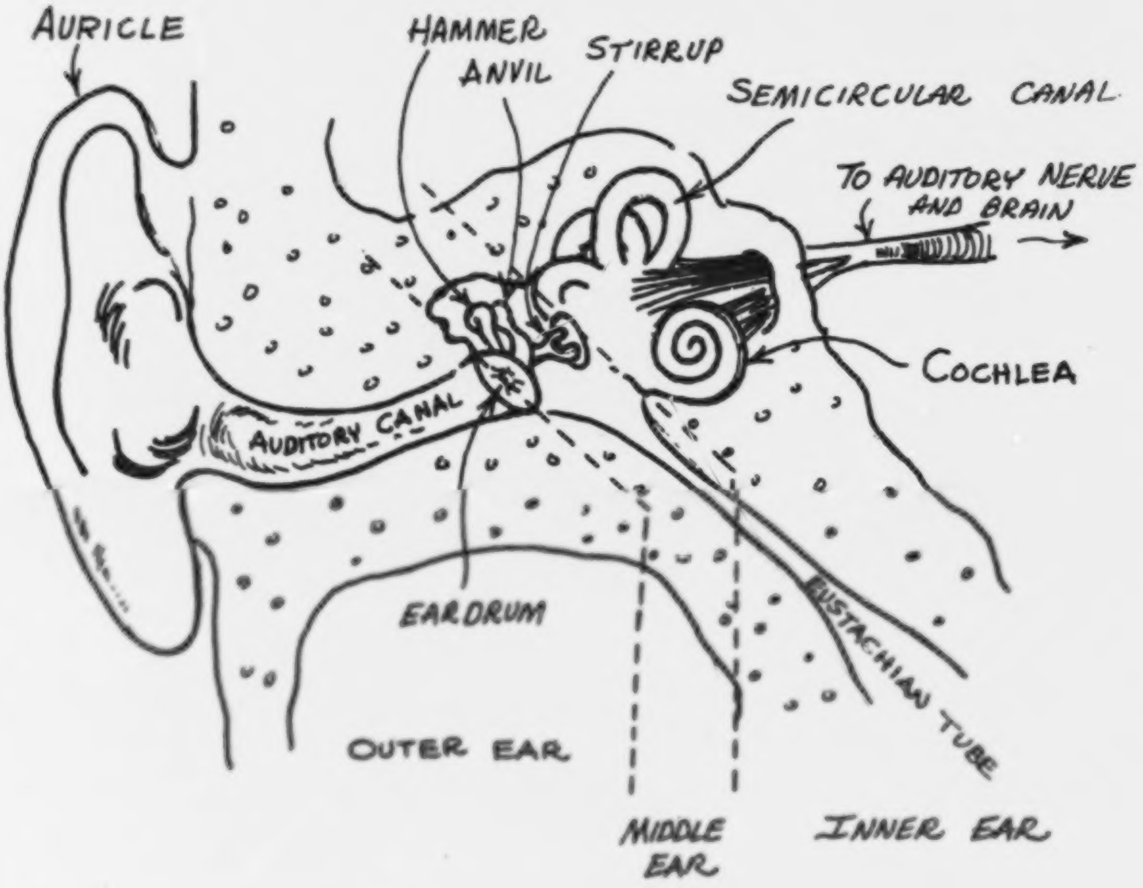
    A. Sound energy is changed to electrical impulses in the telephone or radio. Electricity and radio waves travel at the speed of light - 186,000 miles per second, which means that electrical energy can travel around the earth at the equator seven and one half times in one second. The electrical impulses in a telephone transmission are changed back to sound waves on the other end of the line. In the case of radio, sound waves are converted to electrical impulses, which are in turn converted to radio waves. These are converted back in the reverse order to sound waves so that we hear them as normal sound.

SOUND

I. OBJECTIVE: The parts of the ear and their functions.

II. MATERIALS:

A. Chart or dissectible model of the ear


AURICLE
HAMMER
ANVIL
STIRRUP
SEMICIRCULAR CANAL
TO AUDITORY NERVE AND BRAIN
COCHLEA
AUDITORY CANAL
EARDRUM
EUSTACHIAN TUBE
OUTER EAR
MIDDLE EAR
INNER EAR

III. PARTS OF THE EAR AND THEIR FUNCTION:

A. OUTER EAR:

1. **Auricle**: To gather and direct sound waves down the auditory canal.

2. **Auditory Canal**: The passageway by which sound waves reach the middle ear.

B. MIDDLE EAR:

1. **Eardrum**: Is a membrane stretched across the end of the auditory canal and the beginning of the middle ear. It vibrates at the same rate as the sound waves striking it. If damaged, it will not vibrate properly.

2. Hammer, Anvil and Stirrup: The three smallest bones of our body, so named because of their shapes. The hammer is attached to the eardrum and is attached to the others by means of ligaments. As the eardrum vibrates, it causes the hammer, anvil and stirrup to vibrate at the same rate.

3. Eustacian Tube: Leads from the middle ear to the back of the throat it helps to maintain an even air pressure on the eardrum, between the outer and inner ear. If you have been at high altitudes in an airplane or in the mountains, or gone up or down a high speed elevator, you have probably felt a change of pressure inside the middle ear. Swallowing or chewing gum will relieve this pressure as the amount of air in the Eustacian tube and middle ear is changed in this way.

C. INNER EAR:

1. Cochlea: Is a snail-like coil filled with a liquid into which the ends of the auditory nerves terminate. The vibration of the stirrup, which is held to thin rear wall of the middle ear, is picked up by these nerves and transmitted to the hearing part of the brain, the front part of the cerebrum.

2. Semicircular Canal: Not a part of our hearing mechanism. Controls our sense of balance. (Equilibrium)

SOUND

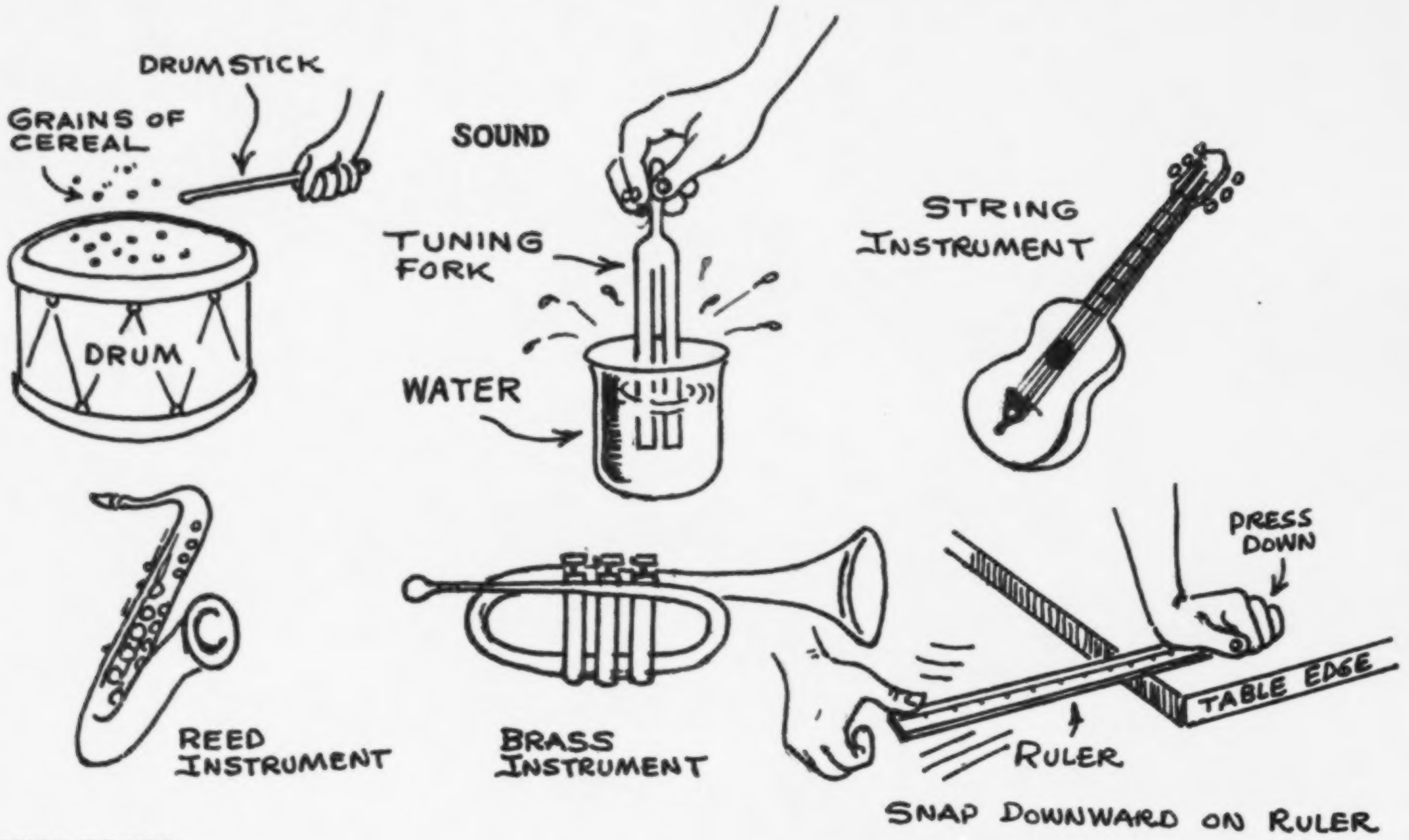
I. **OBJECTIVE**: To demonstrate that sound originates from vibrating objects.

II. **MATERIALS**:

- A. Tuning fork and rubber mallet
- B. Pan or beaker of water
- C. Drum
- D. Cereal, such as Rice Krispies
- E. Radio, with speaker exposed
- F. Violin, guitar or other stringed instrument
- G. Saxaphone or other reed instrument
- H. Trumpet or other brass instrument
- I. Ruler

III. **PROCEDURE**:

- A. Strike tuning fork with the rubber mallet or on rubber heel of shoe and dip prongs into the pan of water. Observe and record.
  CAUTION: DO NOT strike the tuning fork on other than a rubber object as the tuning fork may be damaged.
- B. Place grains of the cereal on the head of the drum and strike. Observe and record. What happens when the drum head is hit harder?
- C. Place grains of the cereal on the diaphragm of the radio speaker. Turn the radio on, with volume at a low level. Observe and record. What happens when the volume is increased?
- D. Pluck a string on the violin or guitar. Place a thin strip of paper against the string while sound is still audible. Observe and record. Very lightly touch the bottom of case with a finger tip.
- E. Have a student play a note on the reed instrument while you hold a thin strip of paper over the exit end. Observe and record.
- F. Now remove the reed from the instrument and have the student attempt to play the same note while you hold the thin strip of paper over the end of the instrument. Where does the sound originate? Observe and record.
- G. Have a student play a note on the trumpet while you hold a thin strip of paper over the end of the instrument. Observe and record.
- H. Have the student blow through the trumpet while you hold a thin strip of paper over the end of the instrument. Observe and record. Have the student explain what he did differently.
- I. Extend one end of the ruler over the edge of a table or desk, holding the short end tightly against table top while you snap the long end. Observe and record



IV. OBSERVATIONS:

A. Water in the pan splashed about showing that the tuning fork was vibrating.

B. The grains of the cereal bounced about when the drum was struck lightly. The grains bounced higher and further when the drum was struck harder. This indicates that the drum head was vibrating as sound was produced.

C. The grains of the cereal bounced about on the diaphragm of the radio speaker. They bounced higher and further as the volume was increased. This indicates that the diaphragm was vibrating as sound was produced.

D. The thin strip of paper vibrated when placed against the string that was plucked, indicating that the string was vibrating. Vibrations could be felt in the case of the instrument when touched lightly with the finger tip.

E. When a note was played on the reed instrument, with the reed in place, the thin strip of paper vibrated. When the reed was removed, air only could be heard escaping and the strip of paper moved away from the end, but did not vibrate.

F. The strip of paper moved out and vibrated when the note was played on the brass instrument. On the second try, only air came through; the paper moved away from the end of the instrument but did not vibrate.

G. Sound could be heard as a result of snapping the ruler, causing it to vibrate.

V. CONCLUSION:

A. The louder the sound, the greater distance through which the object is vibrating.

B. In the case of the violin or guitar, the string vibrated, causing the air in the case to vibrate, which in turn caused the wooden case to vibrate.

C. In the case of the reed instrument, the reed vibrates, causing the column of air in the instrument to vibrate, thus creating sound.

D. In the case of the brass instrument, the persons lips vibrate, causing a column of air to vibrate and create sound.

E. All sounds result from a vibrating object.

ADDITIONAL INFORMATION:

A. In a piano, wires are caused to vibrate when struck with felt covered hammers. This causes the air inside the piano to vibrate, which in turn causes the wood of the cabinet to vibrate.

NOTE: Check the length of the wire as compared to the pitch of the note.

B. A church pipe organ produces sound by means of air passing through the long pipes and being forced out through small openings, causing vibrations which we hear as musical notes. The air passing through the pipes originates from a compressor, usually located in the basement of the church or in some other remote location.

C. Electric organs produce sound by first producing electrical impulses in tubes or transistors, these impulses are then amplified through a series of electronic components. The signal is then sent to the speaker, causing the diaphragm to vibrate. As the diaphragm vibrates, the air is set in motion and we hear or interpret these vibrations as musical notes.

D. CHECK THE FOLLOWING TO SEE WHAT VIBRATES:

1. Policeman's whistle
2. Xylophone
3. Flute-a-phone
4. Clock ticking
5. Person talking
6. Person whistling
7. Noise from a typewriter
8. Noise from air conditioner
9. Church bell
10. Katydid
11. Mosquito
12. Squeaky door
13. Dripping faucet
14. Sound of the ocean
15. Roaring wind

SOUND

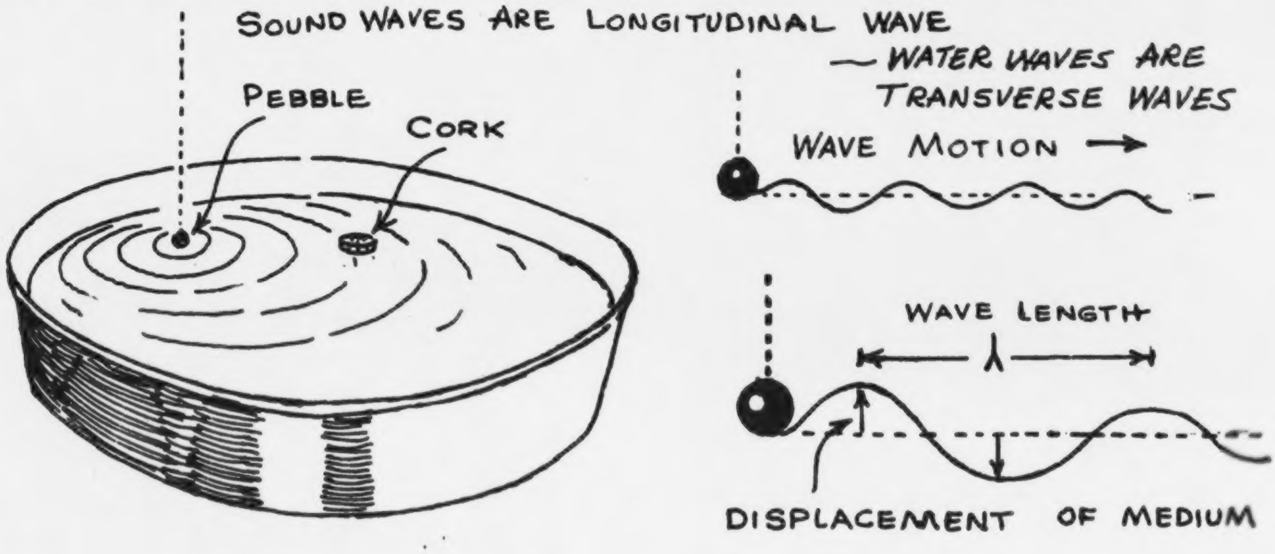
I. OBJECTIVE: To demonstrate how sound waves travel

II. MATERIALS:

A. Large shallow pan or tub
B. Water
C. Small piece of cork
D. Small pebbles

III. PROCEDURE:

A. Place the piece of cork in the water in the tub; observe the position of the cork.
B. Drop a small pebble in the water near the cork and observe.


SOUND WAVES ARE LONGITUDINAL WAVE
— WATER WAVES ARE TRANSVERSE WAVES
PEBBLE
CORK
WAVE MOTION →
WAVE LENGTH
λ
DISPLACEMENT OF MEDIUM

IV. OBSERVATION:

A. Waves moved outward in all directions from the place where the pebble was dropped.
B. The cork did not move outward ---- it simply moved up and down.

V. CONCLUSION:

A. The cork did not move outward because the water did not move outward.
B. The wave travels in the water but the water itself only moves up and down.
C. Sound waves travel through the air in much the same manner. The sound waves travel through the air, but the air itself does not move. (See #16 of introduction)

SOUND

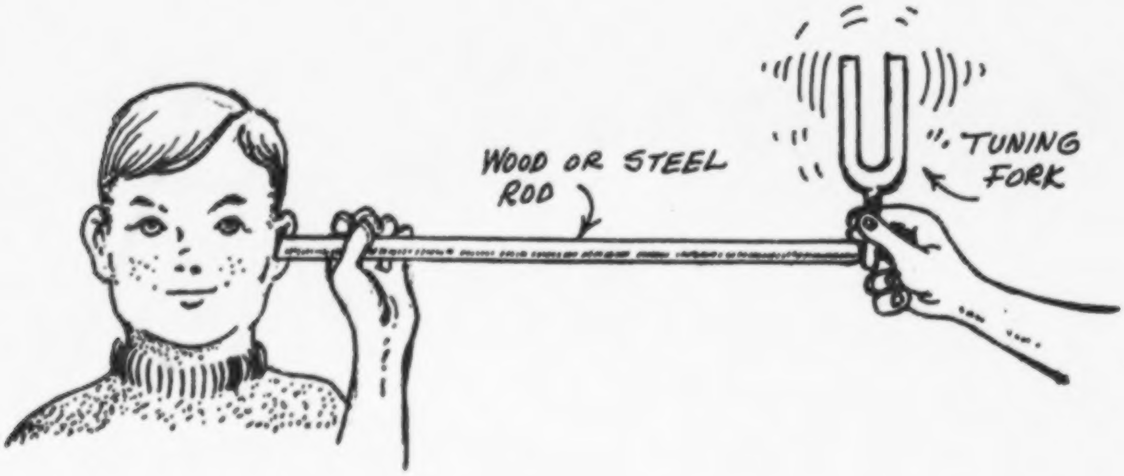
I. OBJECTIVE: To show that solids are good conductors of sound.

II. MATERIALS:

- A. Broomstick
- B. Steel rod about same diameter and length as broomstick
- C. Tuning Fork
- D. Watch
- E. Two students

III. PROCEDURE:

- A. Hold one end of the broomstick to your ear and the handle of a vibrating tuning fork to the other end. Record observations.
- B. Hold one end of the steel rod to your ear and the handle of a vibrating tuning fork to the other end. Compare with the broomstick. Record observations.
- C. Repeat A and B, this time holding the back of a watch to the end of the broomstick and the steel rod. Record observations.



SOUND

IV. OBSERVATIONS:

A. The sound of the tuning fork was louder through the broomstick than through the air.

B. The sound of the tuning fork was louder through the steel rod than through the air and through the broomstick.

C. The ticking of the watch could be heard clearly through the broomstick and the steel rod. It was louder through the steel rod than the broomstick.

V. CONCLUSION:

A. Solids are very good conductors of sound.

B. Solids are better conductors of sound than air.

C. Steel conducts sound about fifteen times better than air.

D. Solids conduct sounds better than liquids.

E. The earth is a solid. The Indians are said to have "put their ears to the ground" to determine whether or not horses were coming in the distance.

F. Miners who have been trapped deep below the ground level have signaled their position by tapping on metal pipes.

G. Sounds from rooms above can readily be heard through solid wood or concrete floors.

H. Sounds travel through liquids and solids better than through air because the molecules are closer together. The molecules of a solid are closer together than the molecules of a liquid.

SOUND

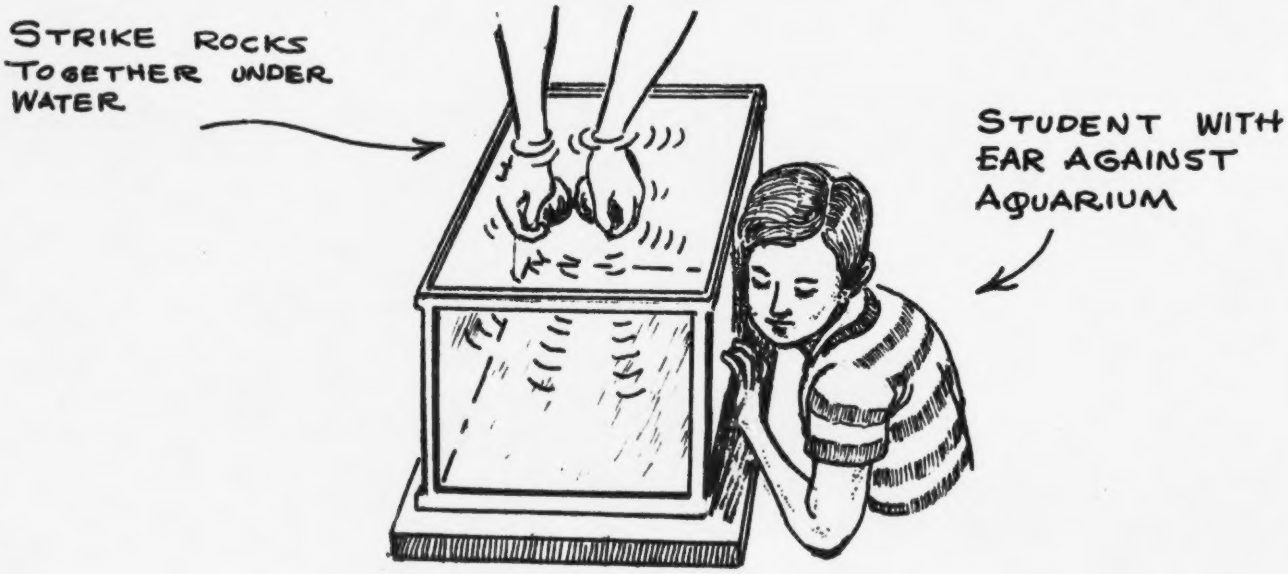
I. OBJECTIVE: To show that water conducts sound better than air.

II. MATERIALS:

A. Aquarium three fourths full of water
B. Two spoons or two fist size rocks
C. Two or more students

III. PROCEDURE:

A. Strike the two spoons or two rocks together under water while another student is holding his ear against the side of the aquarium. Observe and record.
B. Strike the two objects together under water while the other student is close to the aquarium, but not holding his ear against the side. Observe and record.
C. Strike the two objects together in the air with the other student about the same distance as in A and B above.
D. Can the sounds be heard better in A, B, or C?


STRIKE ROCKS TOGETHER UNDER WATER
STUDENT WITH EAR AGAINST AQUARIUM

IV. OBSERVATIONS:

A. The sound of the objects striking together was louder when they were under water and the ear held to the side of the aquarium.

V. CONCLUSION:

A. Water is a better conductor of sound than air.
B. Sound travels about four times faster in water, therefore is about four times louder when heard under water than in the air.

SOUND

ADDITIONAL ACTIVITY:

A. When you are swimming, compare the sound of a motorboat under water to that above water.

B. When swimming, have a friend move off about two hundred or more feet and bang two rocks together under water while you are swimming underwater. Compare the sound with the banging of the rocks in the air while your head is above water.

SOUND

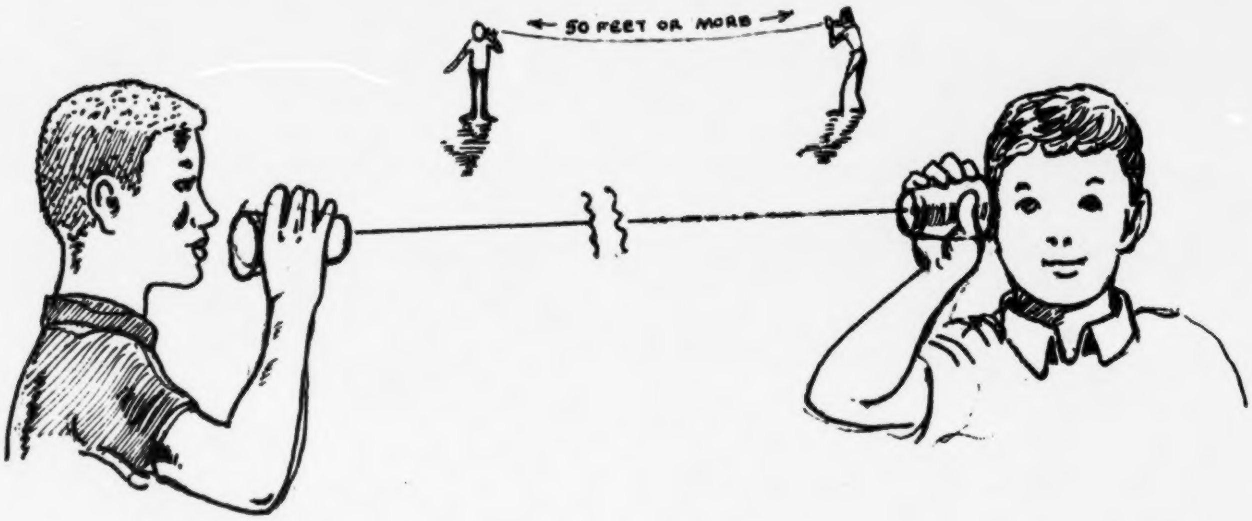
I. OBJECTIVE: To construct a string telephone and explain how it works.

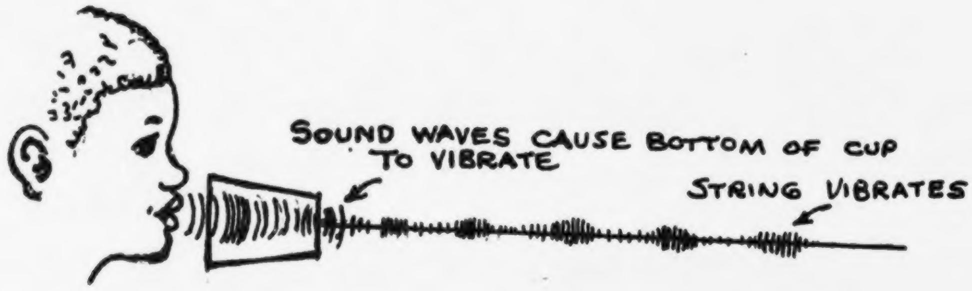
II. MATERIALS:

- A. Two paper or plastic cups or two tin cans
- B. Fifty or more feet of string
- C. Sharp pencil or nail

III. PROCEDURE:

- A. Make a small hole in the bottom center of each cup or can, using the pencil or nail point.
- B. Pass the string through each hole, from the outside in, and make a knot large enough that the string will not pull through the hole.
- C. Stretch the string tight, having one student hold the cup to his ear while the second student talks into the opposite end.
- D. What happens if the string is not kept taut?
- E. What happens if the string is allowed to touch another object while talking?


50 FEET OR MORE


SOUND WAVES CAUSE BOTTOM OF CUP TO VIBRATE
STRING VIBRATES

IV. OBSERVATIONS:

A. The words of the classmate could be heard loud and clear through the string telephone.

B. If the string was not held taut, the conversation could not be heard through the string telephone.

C. If the string between the two cups was allowed to touch another object, the conversation between the two students could not be heard.

V. CONCLUSION:

A. The bottom of the paper cup vibrates at the same rate as the sound waves created by the students' voice. This in turn causes the string to vibrate at the same rate. The string in turn causes the bottom of the other paper cup to vibrate at the same rate. The ear then receives these vibrations and interprets them as sound.

B. Sounds could not be heard when the string was not tight because it could not vibrate.

C. Sounds could not be heard when the string touched another object because the vibrations were interupted and did not reach the opposite cup.

D. The string telephone carries the sound better than the air.

E. The bottom of the paper cup acts as a diaphragm, vibrating in unison with the sound waves that strike it.

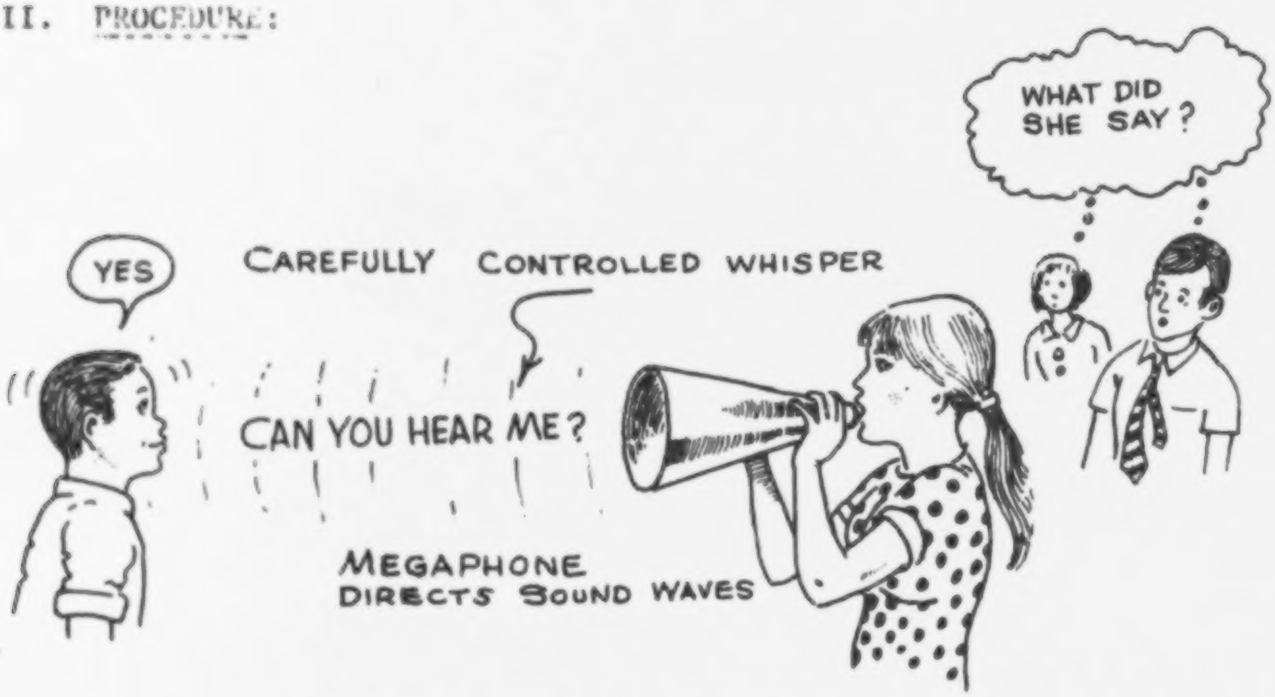
SOUND

I. OBJECTIVE: To demonstrate and explain how a megaphone works.

II. MATERIALS:

- A. Megaphone or piece of posterboard from which one can be made
- B. Tape or stapler

III. PROCEDURE:



WHAT DID SHE SAY?
YES
CAREFULLY CONTROLLED WHISPER
CAN YOU HEAR ME?
MEGAPHONE DIRECTS SOUND WAVES

A. If megaphone is not available, construct one by using the posterboard and tape.

B. Divide the class into two groups, having each group sit on opposite sides of the room.

C. Have a student whisper a number to the group on the left side, using the megaphone.

1. Do the students on the left hear this whispered number?

2. Do the students on the right hear the whispered number?

D. Have the same student whisper a number without using the megaphone.

How many of the students hear the whispered number?

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ILABLE AT TIME FILMED

E. Have the student cup his hands about his mouth and whisper a number to the group on the right:

    1. Do the students on the right hear the whispered number?

    2. Do the students on the left hear the whispered number?

IV. OBSERVATIONS:

A. Only the students on the side towards which the megaphone was pointed heard the first whispered number.

B. Most students on each side of the room heard the whispered number when a megaphone or cupped hands were not used.

C. Only the students on the side towards which the cupped hands were pointed heard the number this time.

V. CONCLUSION:

A megaphone or cupped hands can direct sound waves and make them appear louder in the direction the megaphone is pointed.

SOUND

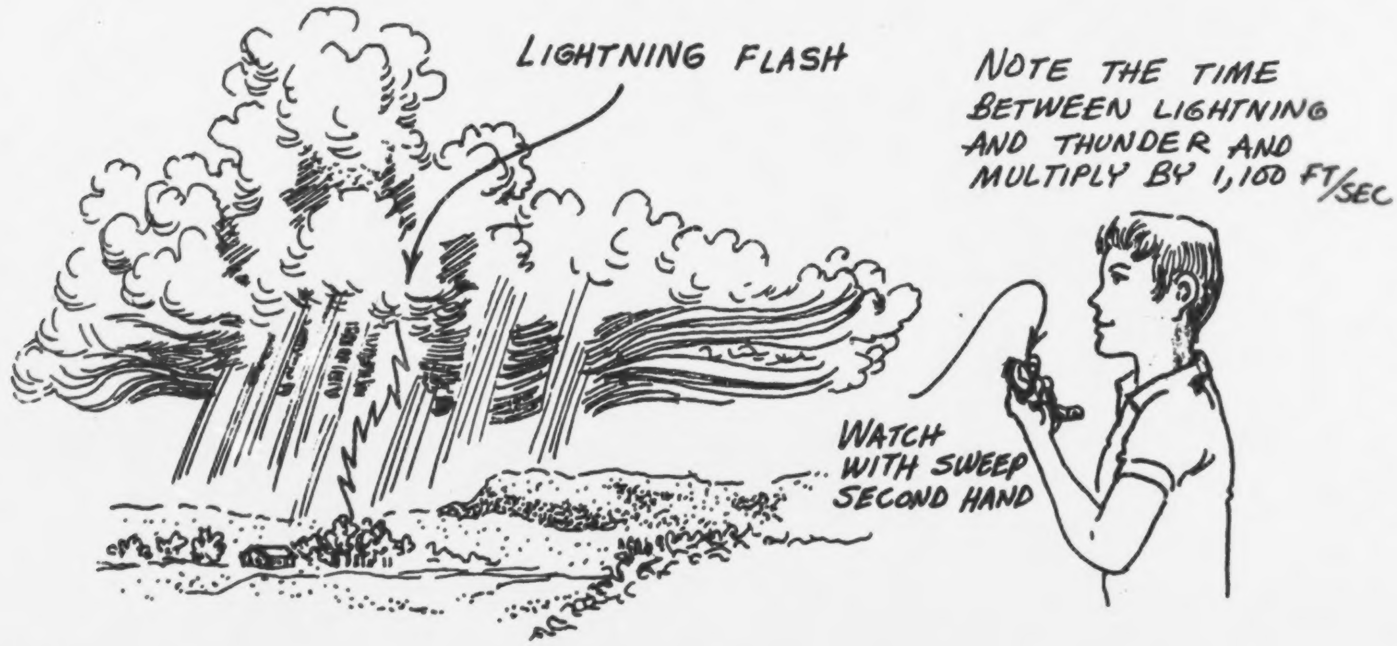
I. OBJECTIVE: To show how the knowledge of the speed of sound can be used to determine the distance of lightning.

II. MATERIALS:

A. Stop watch or a watch with a sweep second hand
B. A thunder storm

III. PROCEDURE:

A. By use of the stop watch or the watch with the sweep second hand, carefull time the interval between the flash of lightning and the sound of the thunder.
B. Multiply the time lapse in seconds times 1,100, ---- the distance in feet that sound travels in one second. This will give you the number of feet the lightning is from your location.
C. Divide the distance by 5,280 (the number of feet in one mile) and you have the distance in miles.


LIGHTNING FLASH
NOTE THE TIME BETWEEN LIGHTNING AND THUNDER AND MULTIPLY BY 1,100 FT/SEC
WATCH WITH SWEEP SECOND HAND

IV. OBSERVATIONS:

A. All lightning flashes from the same storm are not the same distance.

V. CONCLUSION:

A. Light travels at a speed of 186,000 miles per second so it reaches us instantaneously. ---Sound travels only 1,100 feet per second, so there is a considerable time-lapse between the flash of lightning and the sound of the thunder that follows.

ADDITIONAL ACTIVITIES:

A. At athletic events fireworks, etc. , this same technique can be used to determine the distance of the starting gun, the fireworks, etc.

SOUND AND SPACE

I. **OBJECTIVE:** To demonstrate that sound waves will not form unless matter is present. (Sound cannot travel in a vacuum)

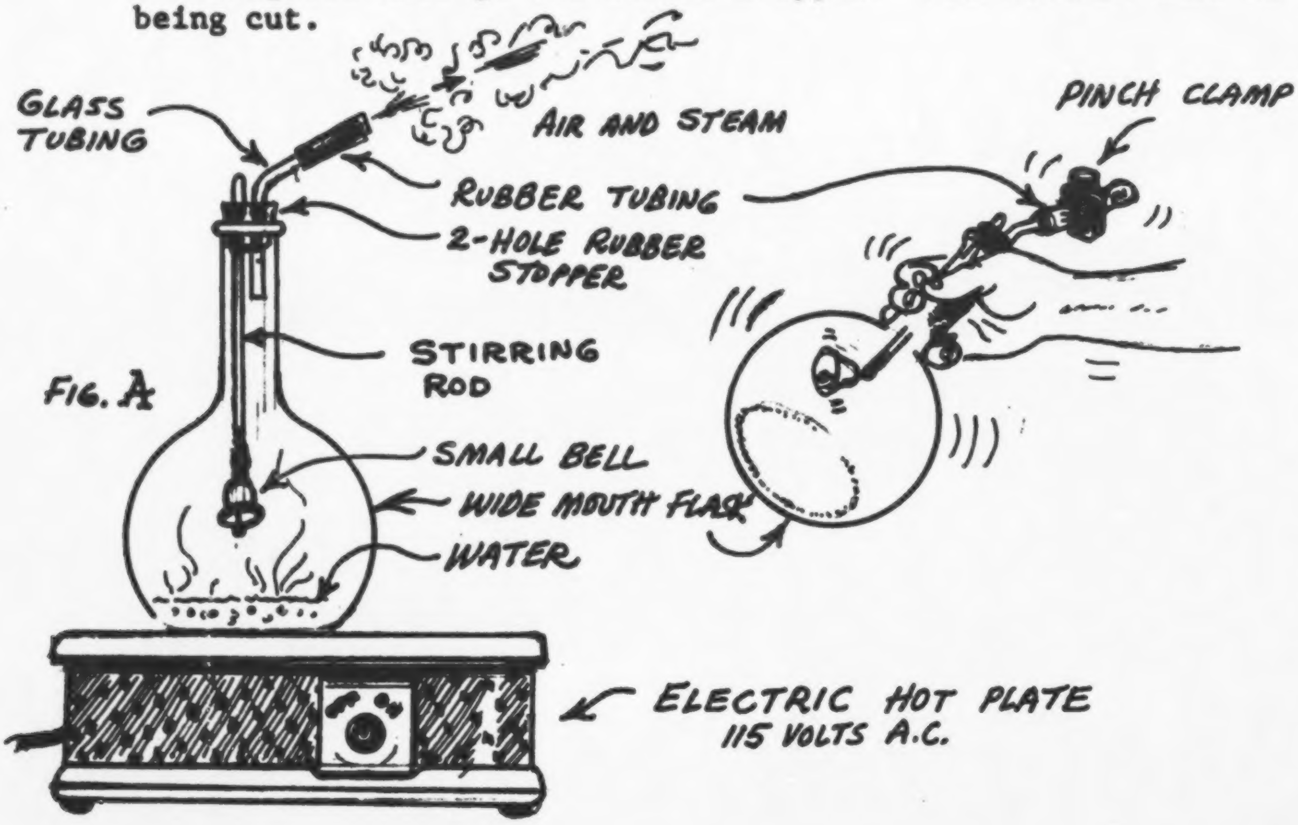
II. **MATERIALS:**

- A. Wide mouth flask with two hole rubber stopper to fit
- B. Small bell
- C. Glass stirring rod
- D. Length of glass tubing
- E. Length of rubber or plastic tubing
- F. Pinch clamp
- G. Thread or tape, or both
- H. Water
- I. Source of heat

III. **PROCEDURE:**

- A. Set up apparatus as illustrated in Fig. A ---- Shake flask to see if you can hear bell.
- B. Boil the water to drive the air out of the flask.
- C. Close the pinch clamp and allow the water and flask to cool.
- D. Again shake the flask and listen for the ringing of the bell.
- E. Allow the air to re-enter the flask and then shake again.

CAUTION: Use liquid soap as a lubricant when inserting the glass tubing and stirring rod through the rubber stopper. Use extreme care to avoid being cut.


GLASS TUBING
AIR AND STEAM
PINCH CLAMP
RUBBER TUBING
2-HOLE RUBBER STOPPER
STIRRING ROD
FIG. A
SMALL BELL
WIDE MOUTH FLASK
WATER
ELECTRIC HOT PLATE
115 VOLTS A.C.

SOUND AND SPACE

IV. OBSERVATIONS:

A. The ringing of the bell could be heard faintly before the water was heated.

B. When the water was heated and the air driven from the flask, the ringing of the bell could not be heard.

C. The ringing of the bell could be heard again as the air entered the flask.

V. CONCLUSION:

A. Sound cannot travel in a vacuum since there is no matter to vibrate.

B. The explosive activity on the sun cannot be heard because there is no air between the sun and the earth.

C. Men in space must communicate with one another via radio since there are no air molecules to form sound waves.

D. Since the moon has no atmosphere, the first astronauts to arrive there will be greeted with an eerie silence and will have to depend entirely upon radio to communicate with fellow astronauts, even though only a few feet apart.

SOUND AND SPACE

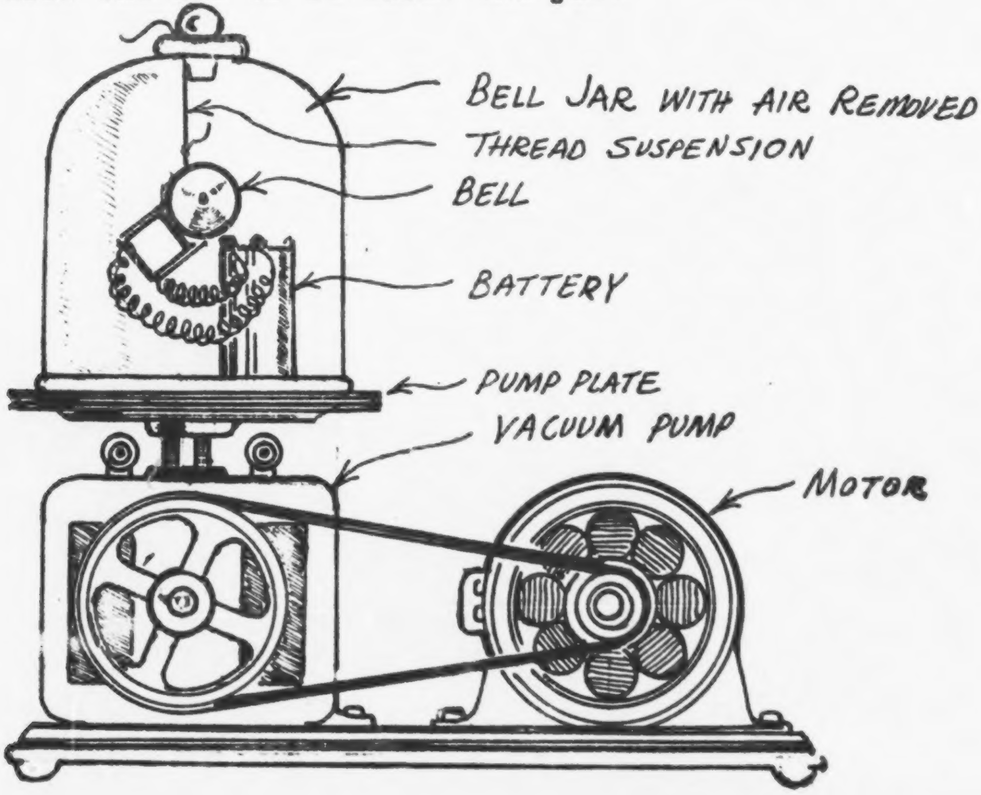
I. OBJECTIVE: To demonstrate that sound waves will not form unless matter is present. (Sound cannot travel in a vacuum.)

II. MATERIALS:

A. Vacuum pump and bell jar
B. Bell and battery

III. PROCEDURE:

A. Hook bell to battery and while ringing, place on pump plate. Cover with the bell jar, making certain the bell is not touching the bell jar or the pump plate.
B. Listen to see if ringing of the bell can be heard.
C. Turn on vacuum pump so that the air in the jar is gradually removed.
D. Stop the pump after a few minutes and listen for the ringing of the bell. If you can still hear the bell, allow the pump to run for several minutes longer.
E. Turn off the pump again and if the bell cannot be heard ringing, feel of the jar and the pump plate to check for vibrations.
F. Slowly allow the air to re-enter the jar.


BELL JAR WITH AIR REMOVED
THREAD SUSPENSION
BELL
BATTERY
PUMP PLATE
VACUUM PUMP
MOTOR

SOUND AND SPACE

IV. OBSERVATIONS:

A. The sound of the ringing bell was muffled when the bell jar was placed over it, however; it could still be heard.

B. As the air was evacuated (removed) the ringing of the bell became fainter.

C. When all or most of the air was removed, the ringing of the bell could no longer be heard.

D. Vibrations could be felt through the pump plate, and to some extent, through the bell jar.

E. As the air was allowed to slowly re-enter the jar, the ringing of the bell could again be heard. The sound became louder as more air entered the jar.

V. CONCLUSION:

A. Sound cannot travel in a vacuum since there is no matter to vibrate.

B. The explosive activity on the sun cannot be heard because there is no air between the sun and the earth's atmosphere.

C. Men in space must communicate with one another via radio, since there are no air molecules to form sound waves.

D. Since the moon has no atmosphere, the first astronauts to arrive there will be greeted with an eerie silence and will have to depend entirely upon radio to communicate with fellow astronauts, even though only a few feet apart.

E. There is no such thing as a perfect vacuum here on earth. Man has not been able to construct equipment that is capable of removing the last molecule of air from an area.

SOUND

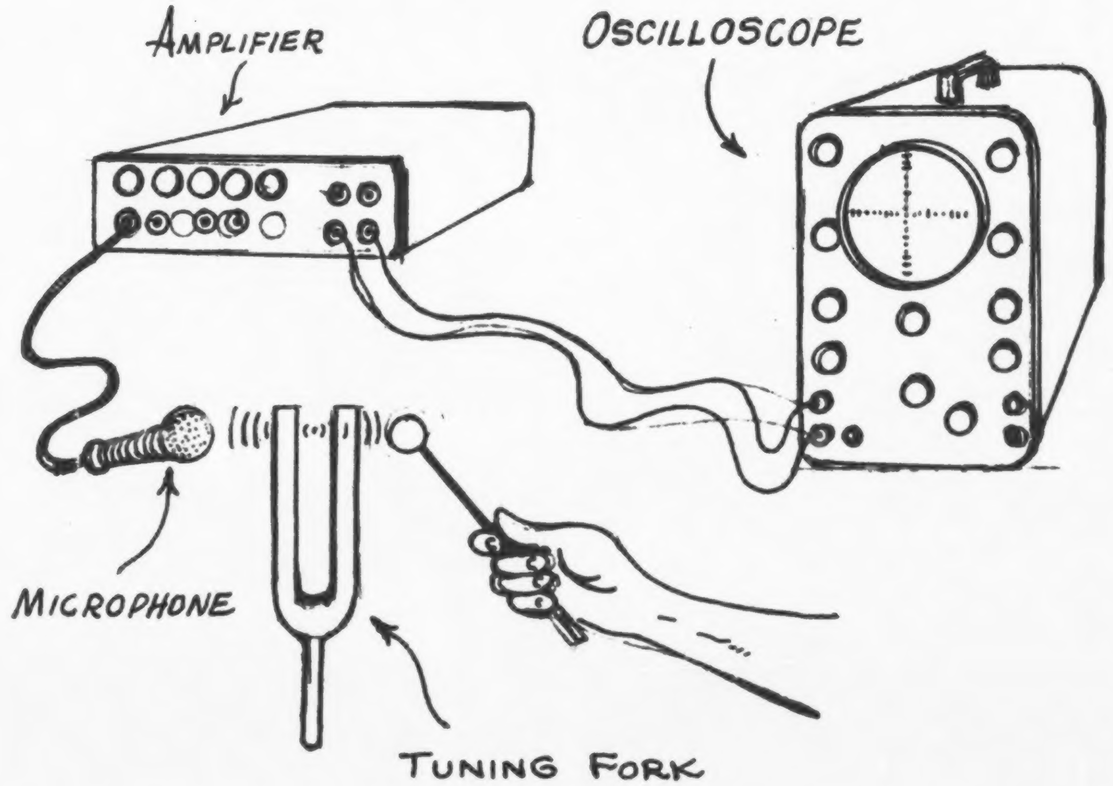
I. OBJECTIVE: To show the difference between frequency (pitch) and amplitude in sound waves.

II. MATERIALS:

- A. Oscilloscope
- B. Amplifier or tape recorder with amplifier and microphone
- C. Tuning forks of different frequencies
- D. Lead wires with alligator clips

III. PROCEDURE:

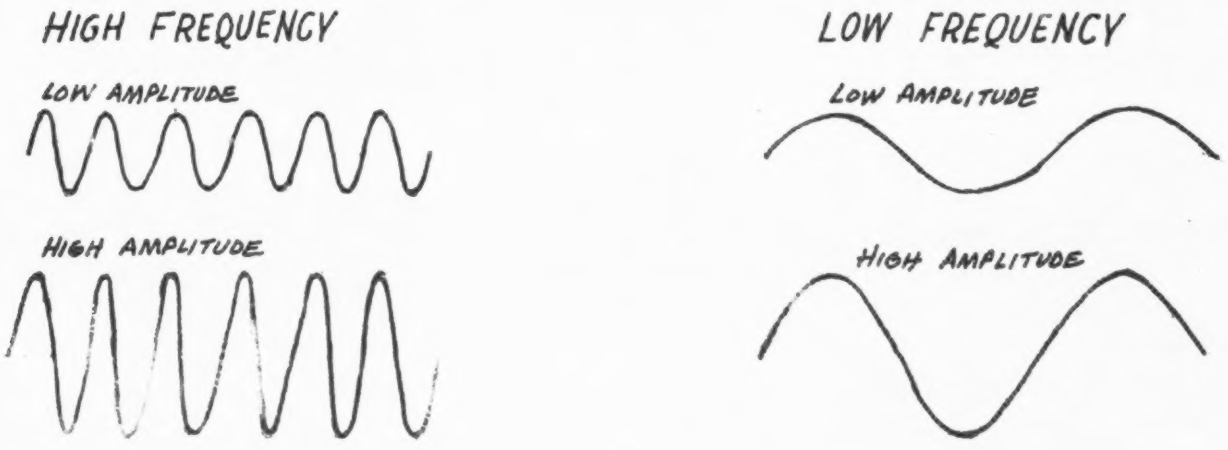
- A. Attach amplifier to the vertical input of the oscilloscope.
  CAUTION: Make certain that you follow the manufacturers procedure in operating the oscilloscope.
- B. Adjust the intensity, focus and other controls so that a horizontal line is centered with the center line of the grid, both horizontally and vertically.
- C. Hold a vibrating tuning fork (125 cps) near, but not touching the microphone. Observe pattern on the screen of the oscilloscope.
- D. Repeat C, using each note of the scale, 128 cps (C_1) through 512 cps (C^1).
- E. If available, use a tuning fork with 1,000 cps and 4,000 cps.
- F. What happens as the intensity of the vibrations decrease?



IV. OBSERVATIONS:

A. The sound waves as seen on the screen were closer together in the higher frequency tuning forks than in the lower frequency forks.

B. As the intensity of the vibrations decreased, the height of the waves on the screen above and below the horizontal line also decreased.



V. CONCLUSION:

A. The higher the frequency (pitch) of sound, the greater the vibrations per second.

B. The higher the frequency (pitch) of sound, the closer together the sound waves.

C. The greater the amplitude (volume) (loudness) of sound, the greater distance the sound waves travel above and below the center line. In other words, the louder sound waves are higher than the softer sound waves.

D. The microphone converts sound waves to electrical impulses. They are increased in size by the amplifier, then converted to light waves on the fluorescent screen of the oscilloscope.

ADDITIONAL ACTIVITY:

A. The students will probably enjoy talking into the microphone and seeing the sound waves created by their own voice. Have them change the pitch of their voice.

B. Connect the wires from the speaker of a radio or phonograph to the oscilloscope and observe the different patterns that appear depending on the frequency of the sound and the volume to which the radio or phonograph has been adjusted.

SPACE

CONTENT:

INTRODUCTION

VOCABULARY

CONCEPT

To construct an all purpose ringstand.

To demonstrate inertia.

To show action and reaction.

To demonstrate Newton's Third Law of Motion - for every action, there is an equal and opposite reaction.

To demonstrate inertia guidance. (gyroscope)

To show what causes balloons to rise.

To demonstrate the effects of aerodynamic lift.

SPACE

Introduction

A. What is space?
Space is considered to be everything beyond the earth's atmosphere. In space, there is an almost total lack of the molecules that make up matter. In the earth's atmosphere, "thin" air is really composed of molecules that are packed tightly together. In space, there are only a few molecules per cubic foot as compared with millions of molecules in a cubic foot of the air we breathe on earth.

B. What does a person hear and see in space?
Because there's no air in space, there is no sound. That's because sound transmission depends on air molecules. When you clap your hands, you hear it because molecules are compressed in waves that strike your eardrum. Since there are no air molecules to compress in space, there is no sound.

The blue of our sky is caused by the way in which molecules and dust particles disperse the light rays. Without them there is no color; therefore, space is black.

C. Is it hot or cold in space?
It is both; the temperature ranges from extreme heat to extreme cold. Because of the density of air on earth, temperatures are moderate, dispersing heat so it never gets too hot, keeping heat so it never gets too cold. In space, there is nothing to retain heat, so it is very,very cold. On the other hand, near the sun or any other star, there is nothing to protect you from the heat. If a person took a sun bath in space, the side facing the sun would burn up, while the side away from the sun would freeze.

D. How do rockets work?
If a person fires a shotgun, a blast goes out the end of the barrel; at the same time, the stock kicks back into his shoulder. That is because every action has an equal reaction in the opposite direction.

Fill a balloon with air, then release it and you have a rocket of sorts. The balloon is moving in the opposite direction from the escaping air; not because it is pushing against anything, that just happens to be a natural law of motion. (Remember that in space there is no air for the escaping gases of a rocket to push against, so we must think of Newton's Third Law of Motion: "For every action there is an equal and opposite reaction.") Fill a large enough balloon with gas and release it, and a lot of weight can be lifted at a very high speed. By this same principle the rocket works.

E. What keeps a spacecraft "up" or "in orbit"?
Think of a weight tied on the end of a long rubber band. Start twirling, and the weight will go in a circle. It will also rise up if you twirl fast enough, until its path will be in a circle parallel to the floor. It is "in orbit" around your finger. Its speed outward balances the pull of the rubber band. The same thing happens with a rocket and earth's gravity, which acts as the rubber band.

F. How does a spacecraft get out of orbit?
There are two ways: either by slowing down, in which case the spacecraft would fall back to earth, or by speeding up, in which case it would go out into space. It is like the weight on the rubber band. Twirl fast enough and the band will break, causing the weight to fly off and out. The same is true for a spacecraft. Increase its speed enough, and it will break the pull of earth's gravity. It will go out of orbit.

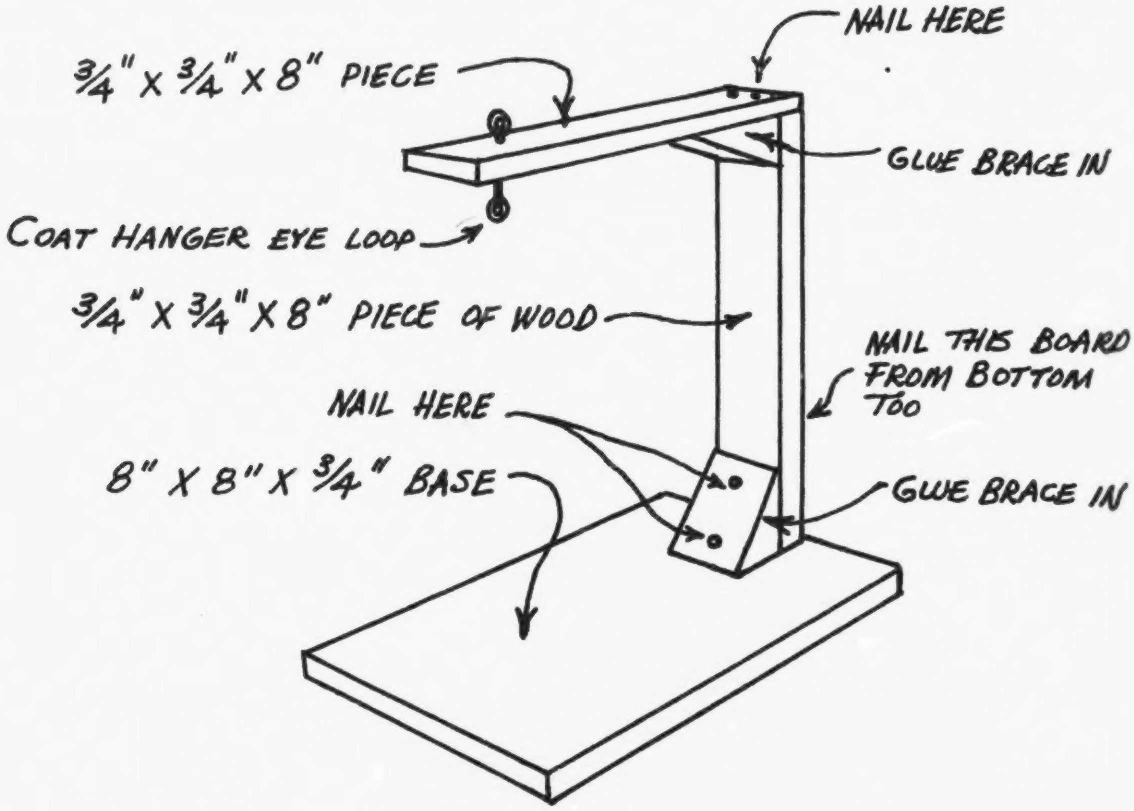
G. Which way is up?
We think of a rocket going "up" from the earth, because the earth is trying to pull it down. But once the spacecraft escapes the earth's gravitational field, and until it enters the effective field of some other body's gravitation, there's no longer a "down". Therefore, there is no up.

RINGSTAND

OBJECTIVE: To construct an all purpose ringstand.

MATERIAL:
1" x 8" square board
1 triangle brace baseside 1-3/4"
altitude side 1-3/4"
1 piece of 3/4" x 3/4" - 14 inches long
1 piece of 3/4" x 1" - 8 inches long
1 wire coat hanger
2 - 6 penny nails
Elmer's glue

PROCEDURE:
A. Use glue on all joints
B. Assemble as shown in diagram


NAIL HERE
3/4" X 3/4" X 8" PIECE
GLUE BRACE IN
COAT HANGER EYE LOOP
3/4" X 3/4" X 8" PIECE OF WOOD
NAIL THIS BOARD FROM BOTTOM TOO
NAIL HERE
8" X 8" X 3/4" BASE
GLUE BRACE IN

CONCLUSION: This ringstand can be used for many demonstrations. Size of ringstand may vary.

SPACE

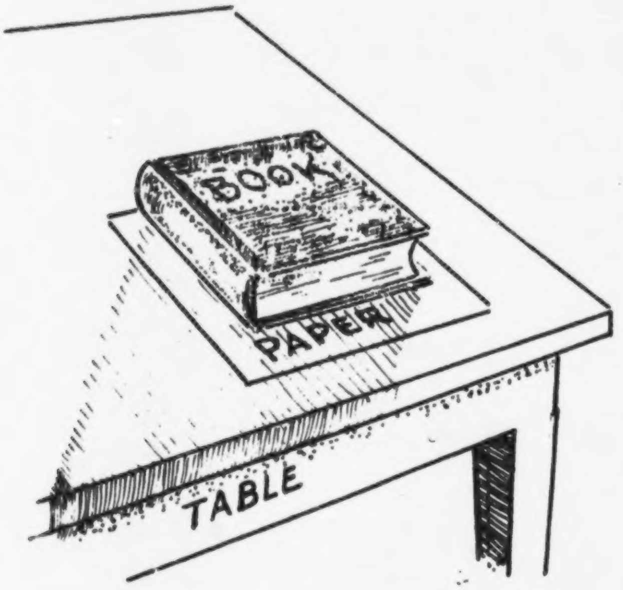
I. OBJECTIVE: Two ways to demonstrate inertia.

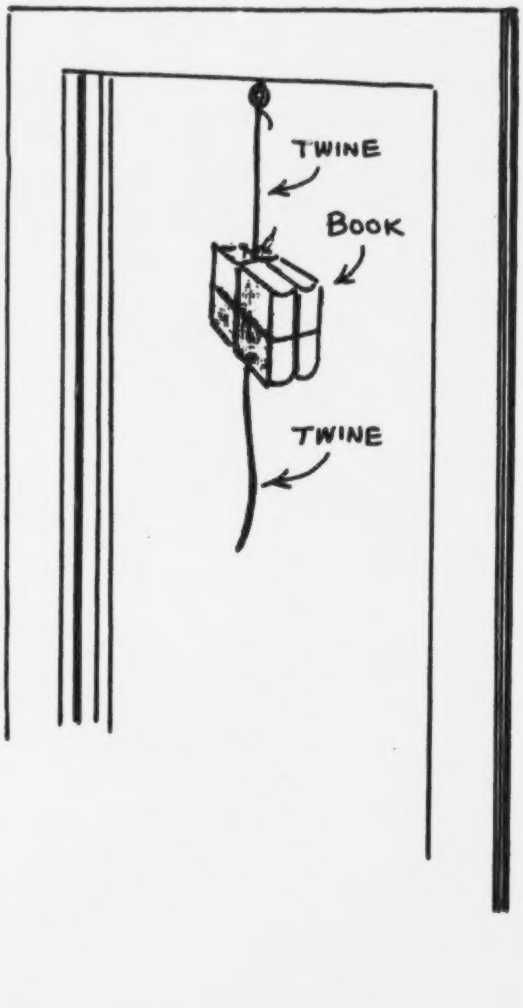
II. MATERIALS:

A. A heavy book or weight
B. One sheet of notebook paper
C. Two 5-foot lengths of lightweight wrapping twine.

III. PROCEDURE:

A. Place the book on the sheet of paper that is lying flat on a table.
B. Slowly pull on the paper and observe. Record observations.
C. Give the paper a quick jerk and observe the book. Record observations.
D. Hang the book or weight from the doorway as illustrated.
E. Pull down slowly on the lower string until one of the strings breaks.
F. Repair the broken string. Now give the lower string a quick jerk. Observe and record.





IV. OBSERVATIONS:

A. The book stays on the paper and moves along with it when the paper is pulled slowly.

B. When the paper is jerked quickly, the book remains practically in place.

C. The top string breaks when the bottom string is pulled slowly.

D. The bottom string breaks when the bottom string is pulled quickly.

V. CONCLUSION:

A. When the paper was pulled slowly, friction of the book against the paper was able to overcome the inertia of rest.

B. When the paper was jerked quickly, the friction of the book on the paper was not sufficient to overcome the inertia of rest.

C. The top string broke when the bottom string was pulled slowly because there was the pull of the gravity on the book, plus the pull of your hand on the top string.

D. The lower string breaks when pulled quickly because the inertia of the book at rest is stronger than the bottom string.

NOTE: Newton's first law of motion is as follows:

> A body at rest remains at rest, or in uniform motion in a straight line unless acted upon by some unbalanced (external) force.

SPACE

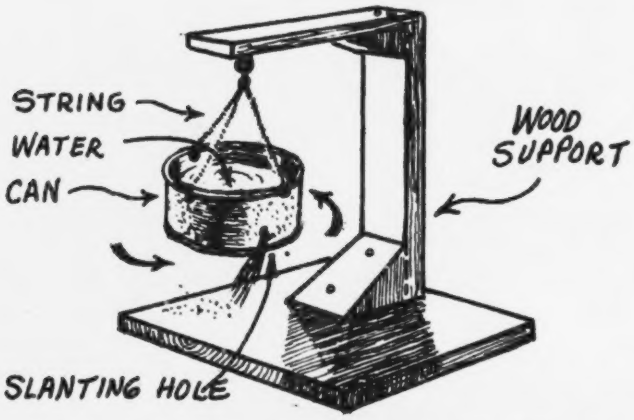
OBJECTIVE: To show action and reaction

MATERIAL:

Ringstand
Nail
Cord
Can
Hammer
Water

PROCEDURE:

1. Punch three holes in side of can at top.
2. Punch hole in can about 1 inch from bottom Bend nail so water will pour out at an angle. Remove nail.
3. Tie cords as shown in diagram and attach to ringstand.
4. Fill can with water and observe as water pours from can.



OBSERVATION:

A. What happens to can as water drains from it?
B. What would happen if angle of lower nail hole was reversed?
C. Does this show how a satellite can be turned by the use of a liquid or gas?
D. What happens to the can when water ceases to flow?
E. How does Newton's Third Law of Motion apply here?

CONCLUSION:

A. The can begins to rotate due to action opposite that of the escaping water.
B. If the angle of hole was reversed, the can would rotate in opposite direction.
C. Satellites and space capsules can be turned in same manner by small rocket engines.
D. When flow of water ceases, the can stops rotating.
E. Newton's Third Law of Motion: For every action there is an equal and opposite reaction.

SPACE

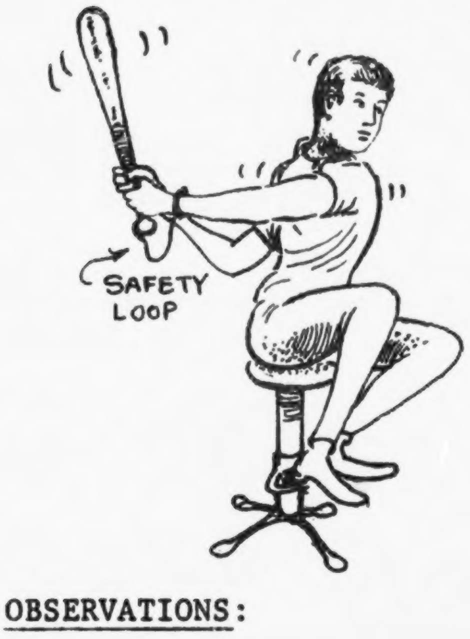
I. OBJECTIVE: To demonstrate Newton's third law of motion -- For every action, there is an equal and opposite reaction.

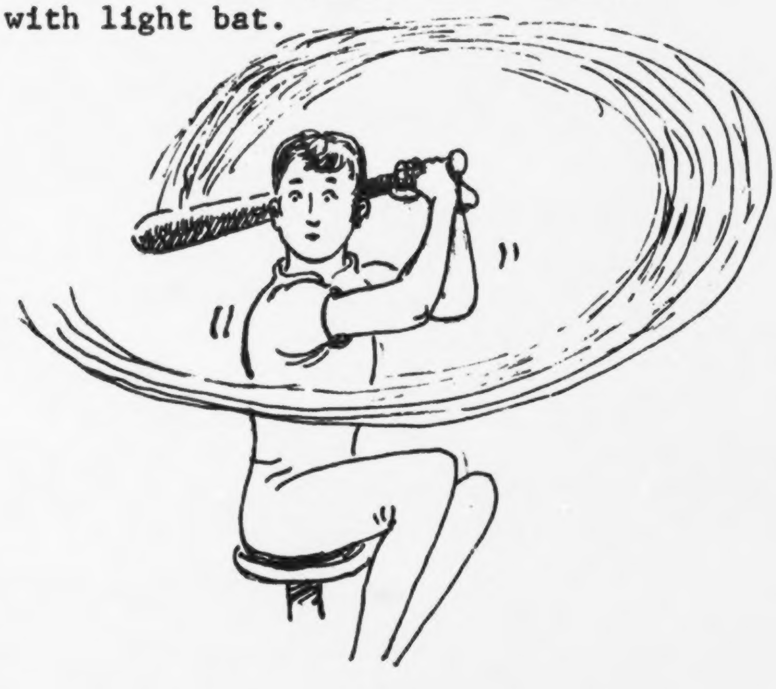
II. MATERIALS:

A. A stool that will rotate freely -- a piano stool will probably do
B. Baseball bats of different sizes and weights

III. PROCEDURE:

A. Have a student sit on the stool with feet free of the floor.
B. When all persons are clear of the stool, have this student swing the lightest bat as hard as possible and observe. Record results.
C. Now have him swing this same bat very easy. Observe and record results.
D. Hand him a much heavier bat, make certain all persons are standing clear, and have him swing the bat as hard as possible. Observe and record. Compare results with light bat.





IV. OBSERVATIONS:

A. There was some movement of the stool when the light-weight bat was swung. The movement of the stool was opposite to the movement of the bat. The harder the bat was swung, the greater the movement of the stool.
B. The stool turned a considerably greater distance when the heavier bat was used as compared to swinging the lighter bat.

V. CONCLUSION:

A. **This proves** that for every action there is an equal and opposite reaction.

ADDITIONAL ACTIVITY:

A. Put on roller skates and stand on a smooth sidewalk with your feet parallel and close together.

B. Throw the ball to a friend who is standing far enough away (and also on roller skates) so that you have to throw rather hard to reach him.

   1. What happens when you throw the ball?

   2. What happens when your friend catches the ball?

C. Repeat "B", but throw the ball harder. Have a third friend measure the change in locations of each person after each throw.

SPACE

I. OBJECTIVE: To demonstrate inertial guidance (gyroscopes)

II. MATERIALS:

- A. Front wheel of a bicycle fitted with wooden handles at the ends of the axles.
- B. String
- C. Free-turning stool (A piano stool may work)

III. PROCEDURE:

A. Set bicycle wheel spinning as rapidly as possible.

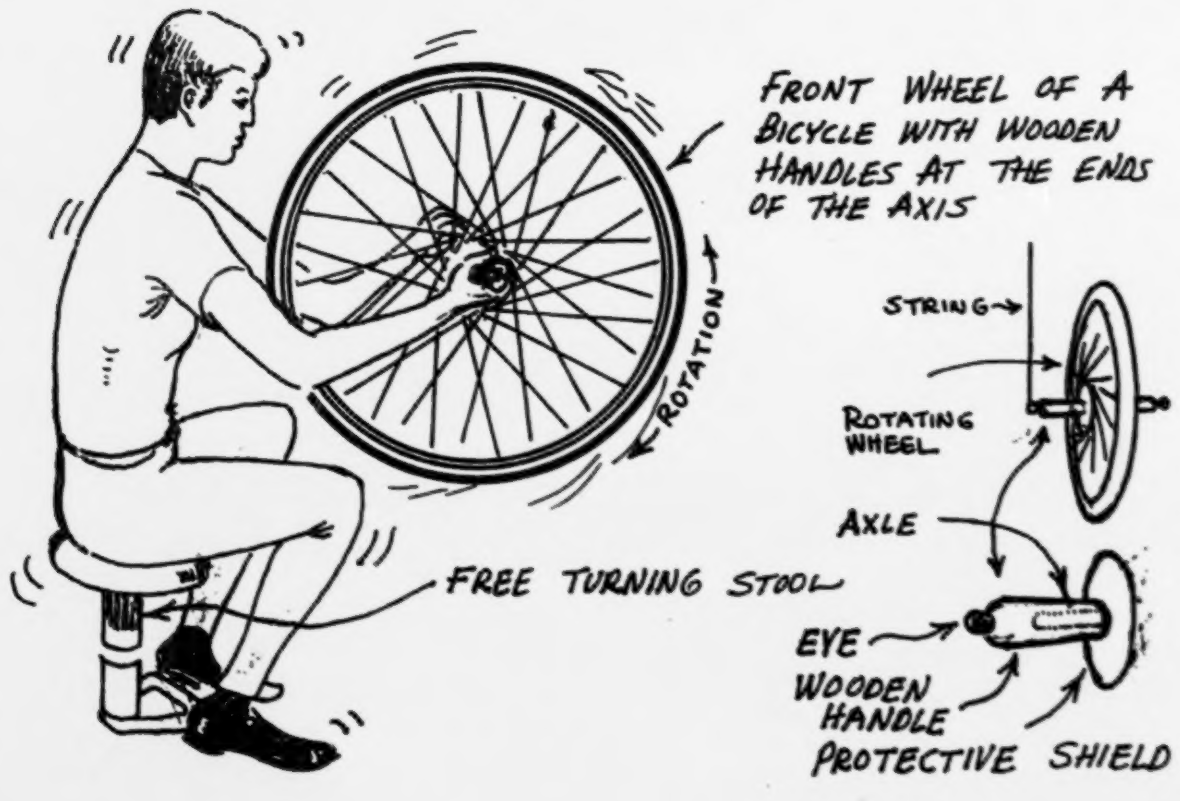
B. Hold by handles and try moving in all directions. Note and record any reactions.

C. Set the wheel spinning again and suspend by one handle with the string. Note and record all actions.

D. Set the wheel spinning again and suspend by the opposite handle. Note and record all actions.

E. Set wheel spinning again, hold by both handles while sitting on the free-turning stool, making certain that both feet are clear of the floor.

1. Tilt the wheel to the right and record any action.
2. Tilt the wheel to the left and record any action.


FRONT WHEEL OF A BICYCLE WITH WOODEN HANDLES AT THE ENDS OF THE AXIS
ROTATION
STRING
ROTATING WHEEL
AXLE
FREE TURNING STOOL
EYE
WOODEN HANDLE
PROTECTIVE SHIELD

SPACE

IV. OBSERVATIONS:

A. There was a resistance to turning the spinning wheel in any direction when it was held by both handles.

B. When the wheel (which was spinning) was suspended by the one handle, it rotated in a clockwise direction; when it was suspended by the opposite handle, it rotated in a counter clockwise direction. This rotation is called precession.

C. When the spinning wheel was held by both handles while sitting on a free-turning stool:

1. The stool turned to the right as the wheel was tilted to the left.
2. The stool turned to the left as the wheel was tilted to the right.

V. CONCLUSION:

A. A gyroscope, or rather, several gyroscopes are utilized in the guidance and stabilization systems of rockets and space capsules.

B. Gyroscopes have been used in the stabilization systems of ships and airplanes for many years . In an aircraft, this system is called the automatic pilot.

C. The gyroscopes in automatic pilots, guidance systems, etc. are motor driven.

D. A gyrocompass, which is more stable, but must be constantly reset with a magnetic compass, works on the same basis. It must be constantly reset due to precession.

SPACE

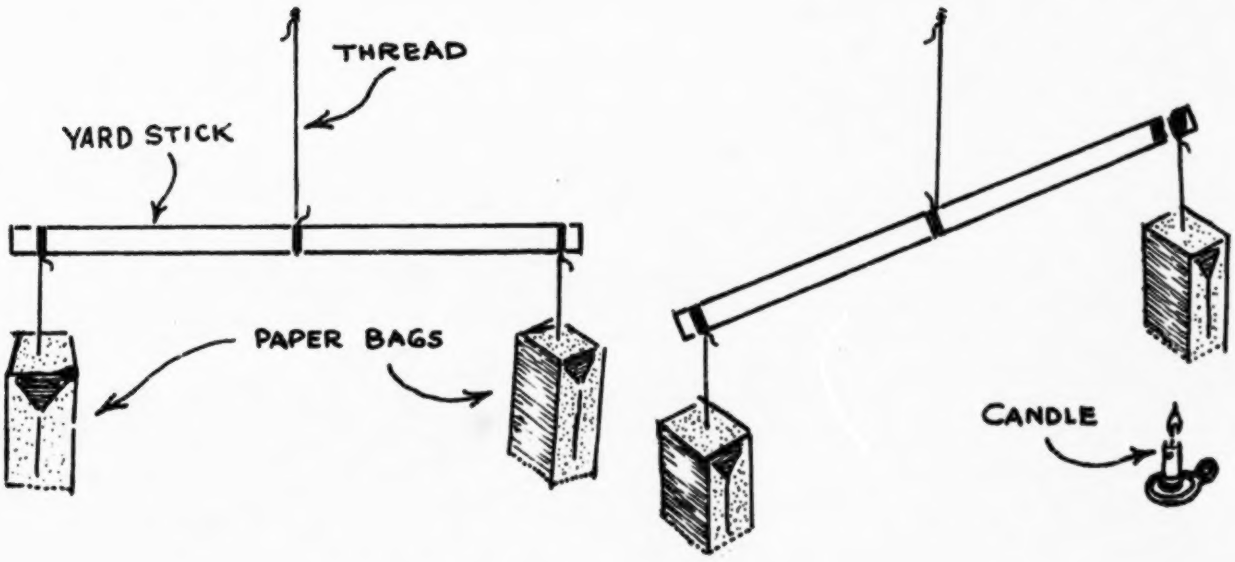
I. OBJECTIVE: To show what causes balloons to rise.

II. MATERIALS:

- A. Yard stick or other long stick
- B. Two paper bags
- C. Thread
- D. Candle or electric hot plate or both

III. PROCEDURE:

- A. Balance the yardstick and paper bags as illustrated.
- B. Hold a lighted candle beneath one of the bags. DANGER - CAUTION WATCH OUT FOR FIRE.
  (If a fire extinguisher is not available, place an electric hot plate beneath the bag.)



IV. OBSERVATIONS:

A. The side of the balance on which the paper bag was heated moved upward.

V. CONCLUSION:

A. When air is heated, it becomes lighter than the surrounding air and rises
B. The heat from the hot plate or candle caused the heated air to fill the bag.
C. The air in this bag being lighter caused the bag to move upwards.

GENERAL INFORMATION:

A. The first recorded balloon flight took place on June 5, 1783 in Annonay, France.

B. The brothers Joseph and Pierre Montgolfier designed and flew this balloon.

C. They filled the balloon with hot air which permitted only limited flight.

D. As the air cooled, it contracted allowing the balloon to settle back to earth.

E. Shortly after this flight, another Frenchman sent up a rubberized balloon filled with hydrogen.

F. Hydrogen gas weighs 5.6 pounds per 1,000 cubic feet; 1,000 cubic feet of air weighs 87.9 pounds, giving a net lift of 82.3 pounds for each 1,000 cubic feet of hydrogen.

G. Hydrogen is very flammable and when discovered, helium replaced hydrogen since it is not flammable.

H. 1,000 cubic feet of helium weighs 11.2 pounds, giving each one thousand cubic feet a net lift of 76.7 pounds.

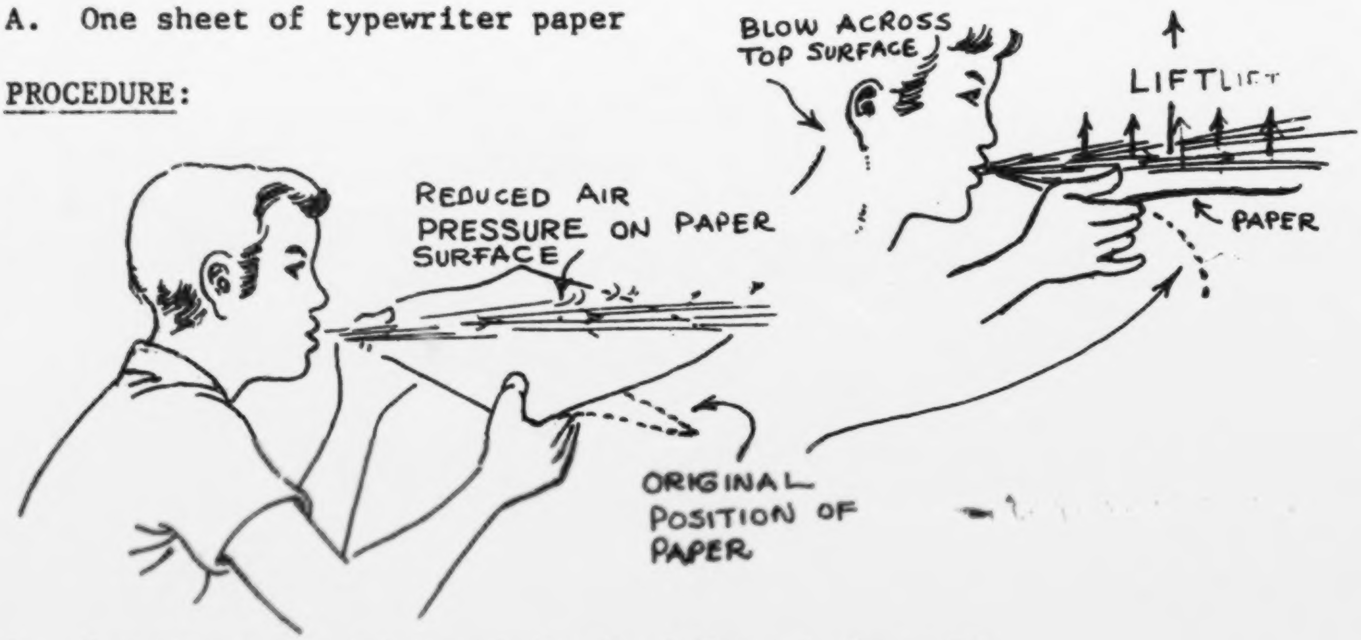
SPACE

I. OBJECTIVE: To demonstrate the effects of aerodynamic lift.

II. MATERIALS:

A. One sheet of typewriter paper

III. PROCEDURE:


BLOW ACROSS TOP SURFACE
LIFT
REDUCED AIR PRESSURE ON PAPER SURFACE
PAPER
ORIGINAL POSITION OF PAPER

A. Cut the paper into a strip about four inches wide.
B. Hold the paper between thumb and index finger and blow steadily across the top of it.
C. Observe and record.

IV. OBSERVATIONS:

A. As you blow steadily across the top of the paper, the end that is not supported lifts upwards.

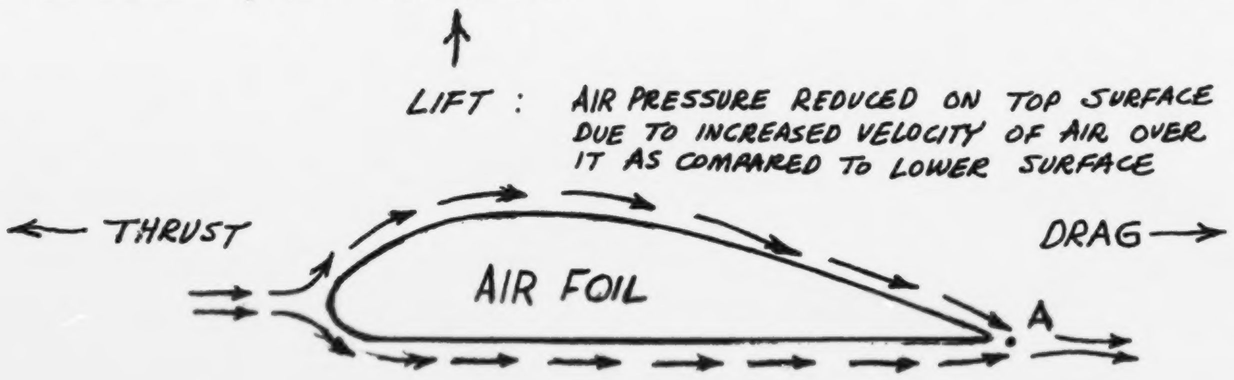
V. CONCLUSION:

A. The paper represents the wing of an airplane.
B. The shape or design of an airplane wing is called an airfoil; it is designed to produce a lift.
C. This is based on Bernoulli's Principle, which states: "As the velocity of a gas or liquid is increased, the pressure perpindicular to the flow is decreased."
D. Daniel Bernoulli (1700-1782) was a Swiss physicist.
E. Air is accelerated as it moves over the top surface of an airplane wing, thus reducing the pressure in this area. The shape of the wing causes the air to move more slowly under the bottom surface, producing a greater pressure there. The net increase in this pressure on the bottom surface results in "lift".

V. CONCLUSION: (cont'd)

F. A propeller or jet engine simply provides the thrust to push or pull the air plane through the air. The wings provide the lift.

G. In the case of the rocket which has no wings, the engines are powerful enough to push the rocket upwards, just as a rock or ball is thrust upward when thrown.


LIFT :
AIR PRESSURE REDUCED ON TOP SURFACE DUE TO INCREASED VELOCITY OF AIR OVER IT AS COMPARED TO LOWER SURFACE
THRUST
AIR FOIL
DRAG
A

H. Air must travel faster over top surface to reach point "A" at same time as air traveling over bottom surface.

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